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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE

FOREST PRODUCTS RESEARCH BOARD

With the Report of the Director of Forest Products Research

FOR THE PERIOD ENDED 31st DECEMBER, 1929

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE PERIOD OCTOBER, 1928, TO DECEMBER, 1929

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

OUR first report, for the period ended September 30th, 1928, reviewed the need for research in forest products, the policy governing our work and the developments that have taken place in it since its inception at the end of 1921. There was also provided therein a background of explanation concerning the character and methods of investigation required, with a description of the apparatus employed. The report now submitted deals with the progress of the work during the period October, 1928, to December 31st, 1929: subsequent reports will be submitted annually, describing the work of each calendar year.

GENERAL

1. The period under review has shown a marked advance not only in the progress made with our programme of research, but also in the use of the results by the public. During this period, 260 inquirers have visited the Laboratory, besides special parties from the Institute of Builders (100), the Southern Counties Federation of Building Trades Employers (100), the Home-Grown Pitwood Section of the Timber Trade Federation of the United Kingdom (9), Board of Education Teachers of Building Subjects (65), the Oxford School of Forestry (20), and the Cambridge University Forestry Society (20). Foreign visitors included research officers from Holland, the Dutch East Indies, Finland, Japan and Czecho-Slovakia. The many letters of appreciation from those who have received technical advice and assistance also bear witness to the value of the work.

VISIT BY THE LORD PRESIDENT OF THE COUNCIL

2. We very much welcomed and appreciated the official visit of inspection paid to the Forest Products Research Laboratory on August 30th by the Lord President, and wish to record our sense of the value of the encouragement which that visit gave to the staff.

INVESTIGATION OF EMPIRE TIMBERS

3. The Report of the Director of Research gives a full account of the progress of the Laboratory's work and the results achieved. We shall therefore here confine ourselves to the more important developments that have taken place in the scope and organization of the work. The chief event of the period has been the expansion of the function of the Board to permit the inclusion of services on behalf of the Empire overseas. The new arrangements find their origin in a request to the Department in January, 1928, from the Imperial Economic Committee in connexion with their inquiry into the marketing in this country of timber and timber products of Empire origin. The Committee asked for a statement of the purpose and activities of the Forest Products Research Laboratory and of the arrangements that could be made there for testing the utility and working qualities of Empire timbers with a view to increasing their use on this market. A memorandum was accordingly presented by the Department describing the origin,

development and scope of the existing organization for forest products research, the objects of the work and the assistance that could be given in respect of Empire timbers, with a survey of the complete system—of which forest products research is only a part —required to provide the full technical and marketing services necessary to promote the utilization of Empire timbers in this country.

4. The Report of the Imperial Economic Committee was duly presented to the Governments of the Empire in August, 1928, and among its proposals was one stating the Committee's opinion that an important service might be rendered to the Empire if arrangements could be made for the Laboratory at Princes Risborough—set up primarily to serve the wood-using industries of Great Britain—to include the testing of Empire timbers as one of its normal functions. The Committee recommended this suggestion to the attention of the Empire Marketing Board, who in due course invited the Department to submit proposals for giving effect to it, together with estimates of the financial consequences involved. Proposals and estimates, based on a 30 per cent. increase of the present scale of the Laboratory's work, were accordingly submitted, and resulted in the offer by the Empire Marketing Board of a capital grant not exceeding £30,000 for the cost of extensions to the buildings and their equipment, with annual payments to cover the running cost of the new work. This offer your Lordships have accepted. Tenders for the work of extending the buildings have been invited and these operations were begun early in the New Year.

5. We would here refer to two important points in the memorandum furnished by the Department to the Imperial Economic Committee. The first is that the primary purpose of the Laboratory is to promote, in the national interest, the more economical use of timber generally by the wood-using industries of this country, the origin of the timber in this connexion being a subordinate consideration. We desire to lay stress on this point. Nine-tenths of our timber imports come from foreign sources, and although we naturally wish to see the increasing substitution of foreign-grown timbers by those of home or Empire origin, yet we would not convey the impression that the user of foreign timber cannot look to the Laboratory for help. The preponderance of our demand on foreign timber makes it obvious that the application of scientific knowledge and method to avoid waste in its use is of prime importance and direct benefit to the community. Nor would we wish it to be thought that such help would be accorded other than willingly.

6. The second point concerns the Department's concluding observation that the technical services that can be supplied by the Laboratory, leading to a determination of the uses to which a new Empire timber could be put, constitute only part of the organization necessary to place and maintain the timber on the market. The marketing of Empire timbers in the United Kingdom to provide for special needs or to displace foreign timber depends on three main factors. First it is essential to have accurate information on potential supplies, their regularity, and cost at the port of arrival in this country. This factor mainly concerns the Forest Services and the Timber Trade and depends on adequate forest and forest-engineering surveys. Secondly, there is the part of this Laboratory in providing accurate technical information on the qualities and uses of the timber. Lastly, the information on supplies and uses must be kept up to date and made continuously available to the using industries. This third factor depends on the existence of efficient marketing organizations connected with the producing areas concerned. In making these observations the Department added that, although, if funds were forthcoming, the Forest Products Research Laboratory was in a position to fulfil the second requirement efficiently, yet the expenditure on such technical services would be largely

wasted unless the first and third requirements were adequately met. This point is of paramount importance.

7. The question of adequate and regular supplies is bound up with adequate forest surveys, not only of the availability of the different timbers but of their botanical identity. An enormous amount of work remains to be done in establishing the identity of a large proportion of the trees that compose our tropical forests. The identification of these timbers with the aid of botanical material from the same tree is a matter of fundamental importance, on which for its ultimate efficiency all the other work, such as the survey of supplies and the testing of the timbers concerned, must depend. We are well aware that the majority of the Forest Services have not the staff sufficient to undertake this work with the thoroughness and rapidity necessary. We would here record our opinion that the development of any scheme for the examination of Empire timbers must inevitably involve improved staffing of the Forest Services and ultimately a comprehensive survey—botanical, statistical and engineering—of the forest resources of the Empire. Unless such steps are taken much of the effectiveness of the new work at Princes Risborough will be lost.

8. Harm has resulted in the past not only from placing a timber on the market without sufficient knowledge of its qualities and the treatment appropriate to it—a trouble that the new arrangements should overcome—but also, perhaps to a greater extent, from the inability of the purchaser to obtain further or regular supplies. Moreover, while it may be expedient to ascertain the technical qualities and commercial possibilities of a timber before expending money on roads and railways for its extraction on an adequate scale, yet without an assurance that regular future supplies can be developed it is not good policy to feel the market by trial shipments. Finally, even when adequate regular supplies are available and a market for the timber has been secured, sales must be followed up by a marketing organization equipped with knowledge of the qualities and peculiarities of the timber which present practical problems in its use. When a new timber, by its merits, replaces one which has been in traditional use in this country, it may often fail to retain favour unless novel difficulties in working are anticipated and expert advice furnished. A contract which does not lead to a repeat order will prejudice rather than promote the utilization of Empire timbers. While the services of the Laboratory are available for supplying technical information and advice, and for assistance in arranging commercial trials, with a view to finding markets for an Empire timber, the task of market creation and extension is not within its functions. This duty primarily devolves both on the Timber Trade and on the trade organizations of the Governments concerned. We would emphasize, in short, that the Laboratory can only aid and not complete the establishment of a timber on the market.

9. In recommending that the task proposed by the Empire Marketing Board be accepted, we also recommended that certain qualifications should be attached to the acceptance. The first of these concerned the bearing of the new work upon our present programme dealing with home-grown timbers and with the problems of the wood-user in this country. These domestic needs are so many and the demands in connexion with them are increasing so rapidly that we are convinced that our existing facilities and the programme of research dependent on them are on a scale that constitutes the minimum necessary to meet the situation. We therefore recommended that the new task should be accepted only if funds were available to cover the running costs involved in providing Empire services without restriction of the existing commitments of the Laboratory or undue dislocation of the programme of research laid down for the present

work. We felt that without this restriction there would be grave risk to the efficiency both of our domestic work on the one hand and the new Empire work on the other. We would here record our satisfaction that the condition has been fully met, as well in the extra accommodation and equipment to be provided as in the basis of the payments to be made for the running costs of the work.

10. The second qualification that we recommended concerned the availability of the Empire timbers submitted for test. While our plans for the new work have been laid on the minimum scale consistent with efficiency, the number of different timbers to be tested from the two million square miles of the Empire's forests, reckoning only those of potential importance, is very large. In order to secure the best value from the work, we therefore felt it necessary to stipulate, as indeed was recommended by the Imperial Economic Committee, that so far as the comprehensive testing of new timbers is concerned the work should at present be restricted to those timbers which are available in quantity and give most promise of finding a market. We therefore recommended that a representation should be made to the Empire Marketing Board pointing out the necessity for the Forest Products Research Board to receive official guarantees that samples of new timbers submitted for test at the Princes Risborough Laboratory are strictly representative of material available in marketable quantities. At the same time we pressed our opinion, as recorded above, that the full effectiveness of the new work depended on a comprehensive survey of forest resources, involving improved staffing of the Forest Services concerned.

11. To assist in the administration of the work, an Empire Timbers Committee has been set up by your Lordships, as a committee of the Forest Products Research Board, with the following terms of reference :—

(1) To advise on all questions of general policy referred to them in connexion with the investigation of Empire timbers at the Forest Products Research Laboratory.

(2) In particular, to decide which of the applications for investigation shall be accepted and to determine the order of priority to be given to accepted applications.

The membership of the Committee is as follows :—

Colonel Sir George L. Courthope, Bart., M.C., M.P., D.L., J.P. (*Chairman*).

Major T. F. Chipp, M.C., D.Sc., Ph.D., Assistant Director, Royal Botanic Gardens, Kew.

J. H. Dimond, Esq., Trade Commissioner in Great Britain for the Union of South Africa (representing the High Commissioner for the Union of South Africa).

F. L. McDougall, Esq., C.M.G., Australian representative on the Imperial Economic Committee.

W. E. McKee, Esq., Past President of the Liverpool Timber Trades Association.

S. G. Tallents, Esq., C.B., C.M.G., C.B.E., representing the Empire Marketing Board.

Professor R. S. Troup, C.I.E., D.Sc., F.R.S., Director, Imperial Forestry Institute, Oxford.

R. V. Vernon, Esq., C.B.
Major R. D. Furse, D.S.O. } representing the Colonial Office.

Harrison Watson, Esq., Chief Canadian Government Trade Commissioner in Great Britain (representing the High Commissioner for Canada).

Eight applications for investigations under the new scheme have already been received. The services now available to the Empire are described in detail by the Director of Research in his part of this Report.

Third British Empire Forestry Conference

12. The Assistant Director, Major F. M. Oliphant, was deputed to represent the Department at the Third British Empire Forestry Conference, held in Australia and New Zealand during August, September and October, 1928, at which for the first time a definite place in the programme was assigned to forest products research. He served on a Committee of the Conference which discussed, among other subjects, the interrelation of the work of the different Forest Products Laboratories, the classes of investigation needed by the various units of the Empire, the development of Empire trade in forest products, and the Tenth Report of the Imperial Economic Committee on Timber. The Conference gave particular endorsement to the recommendation of the Imperial Economic Committee for the extension of the activities of Princes Risborough to cover the testing of Empire timbers. In view of the Empire services that we are now to provide, the visit was of particular value in affording the opportunity of explaining at first hand the organization and work of the British Laboratory, and of making the acquaintance of delegates representing every quarter of the Empire. Much information was collected and, in turn, many inquiries and several proposals for investigation have been received as a result of the Conference. On the return journey, Major Oliphant visited the Canadian Forest Products Laboratories at Vancouver, Ottawa and Montreal. A joint investigation, details of which are given in the Director's Report, has been begun in co-operation with the Vancouver Laboratory.

Courses of Study for Empire Research and Utilization Officers

13. In relation to the new Empire work, we would draw attention to the increasing use that is being made of the Laboratory by the various parts of the Empire in connexion with the training of their research and utilization officers. Since our last Report six more officers have been attached to the Laboratory to study various branches of the work and others are to attend during the coming year. Up to the present time, eleven such officers have been attached to the Laboratory; in addition, four officers of the Laboratory staff have accepted appointments overseas.

Centralization of Outlying Sections

14. At the time when the Laboratory was first occupied, sufficient accommodation was not available to provide for all the units. The Section of Wood Technology was therefore left in quarters rented from the Imperial Forestry Institute, Oxford; the Section of Mycology was left under similar arrangements at the Imperial College, London; while later the Section of Chemistry was also accommodated at Oxford, two of the staff at the Old Chemistry Building, by the courtesy of Professor Soddy, and one at the Dyson Perrins Laboratory, by the courtesy of the late Professor Perkin. Frequent consultation is necessary with these Sections, whose work is also intimately related to that of the Sections at Princes Risborough. Thus, with the development even of our domestic work, this decentralization has become increasingly disadvantageous. With the prospect, on account of Empire services, of adding 30 per cent. to the existing programme of work

it became apparent that the additional facilities to be provided for these services must include centralization of the outlying Sections, as an essential condition of accepting the new task. Under the arrangements with the Empire Marketing Board provision for this purpose has accordingly been made. This centralization will be of direct benefit not only to the administration and progress of the work, and in economy of time and money, but also to inquirers visiting the Laboratory. In many cases, an inquiry primarily relating to one of the Sections now at Princes Risborough also bears on the work of one or more of the Sections housed in London or Oxford. On centralization, officers of these outlying Sections will be immediately available for consultation.

Co-operation with the Imperial Forestry Institute

15. In anticipation of the removal of our Section of Wood Technology from Oxford to Princes Risborough, your Lordships have recently sanctioned the payment of an annual grant to the Imperial Forestry Institute sufficient to provide for the addition of two wood technologists to the Institute's staff, with the necessary laboratory assistance and equipment, and to meet the running cost of undertaking on our behalf certain work concerned with the identification of timbers. At present only one of these additional wood technologists has been appointed, as from last June. Under existing arrangements, with our staff at Oxford, this work is shared with the Institute. We pointed out in our first Report that the work of the Institute in wood technology is very similar to that of the Laboratory, the Institute, however, being concerned with the anatomy of woods with reference to the silvicultural methods calculated to produce the highest quality of timber, whereas the Laboratory is interested from the standpoint of the appropriate uses for the timber. In the past, the two organizations have, as we said, worked on what is virtually a joint programme. The common ground is most evident in respect of the identification of woods. As a training institution, it is a function of the Institute to teach both systematic forest botany and the means of identifying different woods through a knowledge of their anatomical structure; it is also one of its functions to provide systematic botanical descriptions of new tree species within the Empire, coupled with descriptions of the anatomy of the wood. For these functions, and for the study of problems connected with the growing tree, the Institute possesses Sections of Wood Technology and Systematic Botany. Almost the only call, on the other hand, that the Forest Products Research Laboratory has to make upon the systematic botanist is to be assured of the botanical identity of the timbers sent forward for test: such assurance depends not only on an examination of the wood structure—which does not always provide conclusive evidence—but on identification from herbarium material collected from the tree to be tested. With this limited object, there is therefore no warrant for a Section of Systematic Botany at the Laboratory. We have accordingly recommended that the work of identifying our timbers for test, together with special work on the description of the anatomical structure of new Empire timbers, would be more conveniently and economically carried out at the Imperial Forestry Institute, which is in a position to supply both services. The arrangement sanctioned by your Lordships also allows us to call upon the Institute for such other services concerning the identification of timber as may be more economically carried out at the Institute rather than at the Laboratory. In addition to the identification of timber for test, there is a large volume of work mainly concerned with requests from the wood-using industries for identifications, some of which are appropriate to the work of the Institute. We may explain that it will still be necessary for our wood technologists to study the anatomy of woods and their identity, with reference to the comparison of species as a guide to the probable uses of new timbers, beside the critical

examination necessary to correlate structure with mechanical and physical properties. Apart from identification *per se*, our staff must therefore be familiar with the structure of a wide range of woods: the identification of timbers is only one application of this knowledge. This second part of the arrangement with the Imperial Forestry Institute will assist us to maintain an even balance between the various branches of study: it will also secure the continuance of the existing close liaison between the two organizations when our staff have left Oxford. This liaison is well illustrated by the recent publication of a bulletin dealing with the structure and identification of British hardwoods, prepared jointly by the senior wood technologist of each organization and issued under the names of the Department of Scientific and Industrial Research and the Imperial Forestry Institute.

Committee on Wood Preservation

16. As stated in our first Report, considerable delay was experienced in making a beginning in the subject of wood preservation, since it was not possible to obtain a fully qualified man to take charge of the work. An engineer from our own staff had to be trained for the purpose by the Director of Research, who had had many years' experience of the subject while in charge of the Economic Branch of the Government of India's Forest Research Institute at Dehra Dun. Further to strengthen the arrangement, we have set up an *ad interim* Committee of experts representing both scientific and commercial interests. The membership of the Committee is as follows:—

E. J. Butler, Esq., C.I.E., D.Sc., F.R.S., Imperial Bureau of Mycology.
Professor V. H. Blackman, Sc.D., F.R.S., Professor of Plant Physiology, Imperial College of Science and Technology.
R. E. Stradling, Esq., M.C., D.Sc., Ph.D., M.Inst.C.E., Director of Building Research.
A. W. Heasman, Esq., M.V.O., O.B.E., H.M. Office of Works.
C. J. Brown, Esq., Engineer, Southern Area, London North & Eastern Railway.
F. O. Barralet, Esq., A.M.I.E.E., M.Inst.M., General Post Office, Research Section.
R. G. Bennett, Esq., General Post Office, Stores Department.
J. W. Munro, Esq., D.Sc., M.A., Assistant Professor of Entomology, Imperial College of Science and Technology.
H. Eustace Mitton, Esq., M.Inst.C.E., F.S.I., British Colliery Owners' Research Association.
Alan E. Munby, Esq., M.A., F.R.I.B.A.
Professor H. Brereton Baker, M.A., D.Sc., F.R.S., Professor of Chemistry, Imperial College of Science and Technology.
W. W. Perrée, Esq., C.I.E.

We are most gratified with the progress made in this branch of our work, and we owe a debt of gratitude to the members of the Committee for the unstinting way in which they have given their services to its development.

Large-scale Investigation into Dry Rot, and the Death-watch Beetle

17. An important development, in which great assistance has been rendered by the Committee on Wood Preservation, concerns the investigation of dry rot and wood-destroying beetles. Decay, in the form known as dry rot, is probably responsible for by far the greater proportion of timber losses and the total expenditure on replacements due to this cause must be very large. Often accompanying dry rot is the Death-watch

beetle (*Xestobium rufo-villosum*), the cause of serious damage to the roofing and structural timbers of many old and valuable buildings in this country, entailing heavy expenditure in attempts to effect a cure. The importance of these two sources of loss finds reflection in the prominence given to their investigation in our programme of research. We have recently reported to your Lordships that our laboratory work has reached that stage where it is imperative, if further progress is to be made, to study from its inception and to follow through the whole course of an attack by these organisms under natural conditions. Houses and buildings already infested with fungus or insect are not available for inspection over any long period, since the owners obviously desire the eradication of all infested material as quickly as possible. Moreover, in such buildings it is not possible to experiment with different types of construction or with preservative treatments. In the case of the Death-watch beetle, we have so far failed to reproduce in the Laboratory exactly the conditions under which this insect is found in practice to be most destructive, and we consider that its study under natural conditions will certainly result in a more rapid increase in our knowledge of its life history. Our last Report alluded to an important indication from the results of our laboratory work, namely, that there seemed almost certainly to exist some symbiotic relationship between fungi and the Death-watch beetle, and we think that valuable work complementary to that in the laboratory could be done by the study of this problem under natural conditions.

18. Your Lordships have accordingly sanctioned the erection at the Laboratory of a special building for this work, to be erected during the coming year. This building, which has been designed by officers of the Building Research Station, will consist of a ground floor and an attic floor divided into compartments embodying different types of construction, with arrangements for control of ventilation and heating and for the removal of certain portions of the timbering for inspection or replacement. The ground floor will be divided into three rooms. The first will be of good construction with open floor, and will embody those types of construction best calculated to afford protection against dry rot ; for example, damp-proof courses and ample ventilation will be provided. The centre room will show open floor and bad construction, without damp course or adequate ventilation. In the third room, various types of solid floor construction will be employed, both good and bad. The floors in each room will consist of a number of sections which it will be possible to isolate from one another or to connect up, as desired. Various timbers and antiseptic treatments will be employed in each, and the floor boards will be removable for inspection. The panelling of these rooms will also be removable : in places the panelling will be continuous up to the ceiling, thus providing continuity of timber from floor to ceiling. The attic floor will be divided into sections in which the heating and ventilating conditions will be different and controllable. The first floor joists will be removable. This floor will be used largely for experiments with the Death-watch and other beetles, and it is proposed to construct it in part with old timbers. In addition to the need of this large-scale work in furthering the progress of laboratory investigations at the stage now reached, such work will be of great value for publicity and educational purposes in demonstrating the principles of building construction calculated to avoid attack by fungi and beetles, various means of protection, and the measures to be taken in dealing with an attack.

The Value of Wood Chemistry

19. In speaking of the investigations into dry rot, we would draw attention to the success which has attended the inauguration of a Section of Wood Chemistry at the

Laboratory. The youngest of the Sections, it is already proving its value to all other branches of our work. Indeed, the fundamental bearing of chemical research on the whole field of our investigations is becoming increasingly apparent ; the value of wood as a structural material—quite apart from its many uses as the raw material for paper pulp, artificial silk and the like—depends very largely upon the nature and properties of the chemical substances composing it. We mentioned in our first Report that we were considering an investigation of the chemical changes that take place in the decay of wood, especially in the early stages. This investigation was undertaken and has already led to the important conclusion that there exists a close similarity in the effect on wood between the incipent stages of " brown rots " on the one hand and mild acid hydrolysis on the other. Knowledge of this kind may well lead to the development of better methods of prevention. In the meantime, as the Director's Report describes in detail, research is being prosecuted on the " white rots," to determine in the first instance whether the incipient stages of the two recognized types of rot are similar in effect. In addition to the chemistry of decay, an investigation is being made into the chemical aspects of the drying of timber, while the Section of Chemistry is also co-operating in the study of the effect of decay in its incipient stages on the strength of wood. Details of this work are given in the Director's Report, and it will be noted that there is an interesting similarity between the curves obtained by the Section of Timber Mechanics showing the rapid decrease in strength with development of fungal attack and those obtained by the Section of Chemistry showing the increase in the alkali solubility of the wood with development of the attack.

Committee on Timber Mechanics

20. It is generally recognized that some of the tests for determining the mechanical properties of timber, employed as the common standard practice by the various Forest Products Research Laboratories, are open to criticism, notably the tests for determining strength in tension and shear. However, as the results of the tests are used for comparative purposes rather than to express absolute values, the tests have been adopted until such time as a better international standard may be introduced. For comparing species with species and grade with grade, tests by the present standard methods are comparable with some two million tests carried out by the different Laboratories : it is mainly in order to make this comparison that tests on new timbers are sought. At the same time we are not losing sight of the fact that there is room for improvement, and the Report of the Director of Research shows that work to this end has already resulted in an improved shear test. Moreover, as an aid to this work and bearing in mind the international character of the testing practice to be reviewed we have set up an expert Committee, whose opinions should command world-wide acceptance, to provide suggestions for the improvement of certain standard tests now in use and for the design of any new tests required, such as an adequate test of the suitability of woods proposed for flooring. The Committee will also advise us generally upon the lines of investigation to be pursued. The constitution of this Committee is as follows :—

Sir J. Alfred Ewing, K.C.B., D.Sc., LL.D., F.R.S. (*Chairman*), lately Vice-Chancellor and Principal, University of Edinburgh.

Professor C. F. Jenkin, C.B.E., M.A., M.Inst.C.E., lately Professor of Engineering Science, University of Oxford.

Professor A. Robertson, D.Sc., M.I.Mech.E., A.M.Inst.C.E., Professor of Mechanical Engineering, University of Bristol.

W. D. Douglas, Esq., F.R.C.Sc.I., A.M.I.E.E., A.R.C.Sc., A.F.Ae.S., Mechanical Test Department, Royal Aircraft Establishment, South Farnborough.

C. J. Chaplin, Esq., M.Sc., M.E.I.C., Officer in Charge of Timber Mechanics, Forest Products Research Laboratory (acts as Secretary to the Committee).

We would here again express our gratitude to Sir Alfred Ewing, Professor Jenkin and Professor Robertson for agreeing to join the Committee and to the Air Council for the services of Mr. Douglas.

Revision of Existing Specifications for Building Timber

21. We would draw attention to the report by the Director of Research upon the conferences now taking place between a sub-committee of the Science Standing Committee of the Royal Institute of British Architects, representatives of the Timber Trades Federation of the United Kingdom, and of the Building Research Station and Forest Products Research Laboratory for the purpose of revising existing specifications for building timbers. This project marks an important advance not only towards the more efficient utilization of timber, but in the closer co-operation of the various interests concerned.

J. C. IRVINE,
Chairman.

January, 1930.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE PERIOD OCTOBER, 1928, TO 31st DECEMBER, 1929

I.—INTRODUCTION

General

The first serial report of the Forest Products Research Laboratory, Princes Risborough, was submitted at a time when the staff had been in occupation of the new quarters for fifteen months. Though it had been possible to carry out a very fair volume of research work during that period, since a nucleus staff had been collected and trained in temporary accommodation at the Royal Aircraft Establishment, South Farnborough, yet much of the time had perforce been occupied in organizing the general routine of the Laboratory, training new staff, perfecting equipment and like matters. With these things accomplished, and the organization consolidated and running smoothly, the period from October, 1928, to 31st December, 1929, now under review, has shown a marked increase in the volume of work produced, the results achieved and in the use made of the Laboratory by the public. Only one difficulty of organization remains, namely, that the Sections of Wood Technology, Chemistry and Mycology occupy outlying quarters, in Oxford and London, due to lack of accommodation at the Laboratory. Happily, this difficulty will disappear at the end of the forthcoming year, when these Sections will be centralized at Princes Risborough as part of the new arrangements required for testing Empire timbers. The services of these Sections are in daily demand either for consultation with the other Sections or with inquirers. Their centralization at the Laboratory will be of the greatest benefit to the work.

A striking feature of the period under review has been the sharp rise in the number of inquirers who have visited the Laboratory. The figure for the past year is 260, besides special parties, totalling 314 members, from various associations. A like increase has taken place in the inquiries by letter. As an instance, the number of major inquiries addressed to the Section of Seasoning in 1927 was 16, in 1928 the figure rose to 62, in 1929 it was 77. In the initial period of the Laboratory's existence, a large share of the inquiries resulted from the liaison work of the Section of Utilization, buf it is gratifying to record that for some time past many of the inquiries received have been the consequence of recommendations from firms who have themselves received the Laboratory's help. Moreover, inquiries are now continually received from abroad, from foreign as well as from Empire sources. These facts attest the progress and value of the work.

On the 31st of December, 1929, the staff of the Laboratory, including that stationed in London and Oxford, numbered 145, made up of: Scientific and Technical staff, 46; Laboratory assistants (boys and girls), 14; Office staff, 16; Industrial staff (including messengers and charwomen), 69. A list of Scientific and Technical staff is given in Appendix I.

Testing of Empire Timbers

A memorandum on the investigation of Empire Timbers has been prepared which gives a full account of an important expansion of the functions of the Laboratory to permit it to undertake certain services for the Empire overseas. The classes of work which it will be possible to carry out, for the Forest Services, other Government

Departments and for commercial organizations, under the new arrangements may be tabulated as follows :—

(*a*) *For Crown Colonies and Dependencies not possessing a Forest Products Laboratory.*

i. Preliminary examination of the anatomical structure of the timbers and small-scale experiments to gauge probable qualities and uses and whether worthy of full-scale test.

ii. Large-scale tests (seasoning, strength, preservation and wood-working) on those timbers found by preliminary investigation to warrant them.

iii. Specialized tests, such as suitability for bending, box-making, plywood and other special uses.

(*b*) *For Dominions possessing their own Laboratories.*

i. " Suitability " tests, with reference to timbers to be offered to the United Kingdom for special uses.

ii. Co-operation work, when the Dominion desires to have some phase of the inquiry carried out in the United Kingdom.

(*c*) *For the Empire as a whole.*

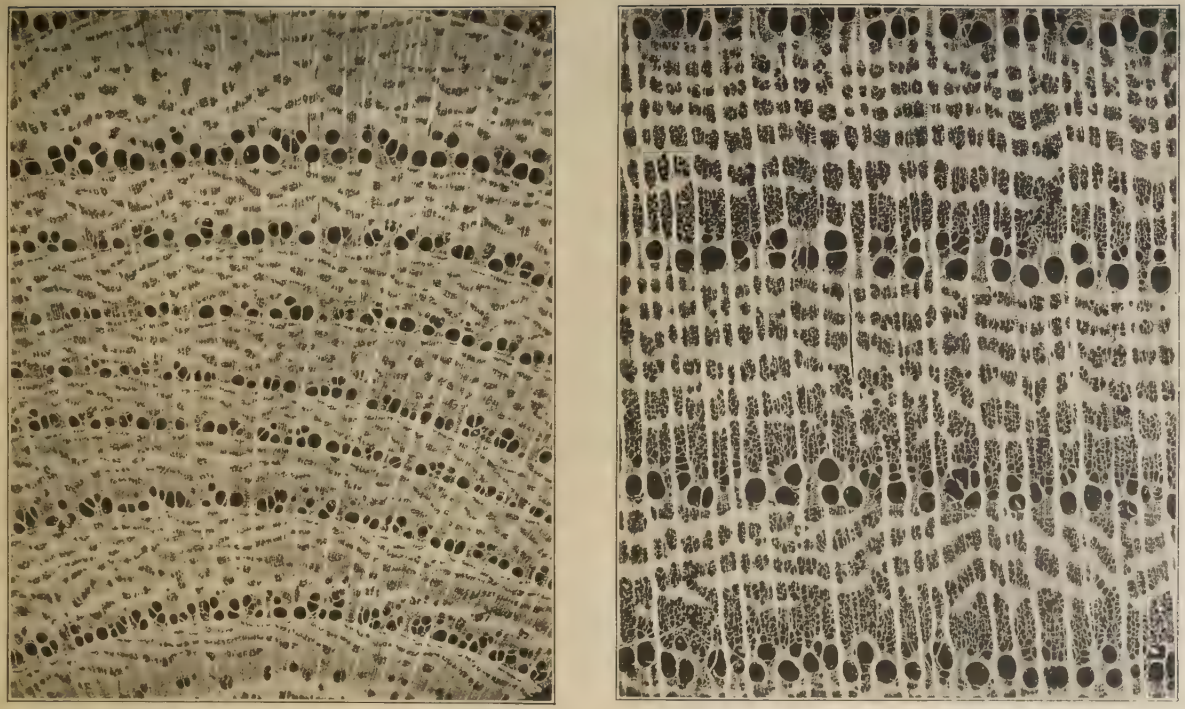
Advisory work on matters within the Laboratory's province, and replies to inquiries about Empire timbers from United Kingdom interests.

Volume of Empire Work possible

In the above classes, it is estimated that it will be possible during the year 1930 to undertake with the existing facilities eight preliminary small-scale investigations under class (*a*) i, two major investigations under class (*a*) ii, and two specialized tests under class (*a*) iii. During the past year, six preliminary investigations have been carried out, but no major tests have yet been undertaken. The amount of work under classes (*b*) i and ii depends upon the character and scope of the proposal. No tests under class (*b*) i have been carried out during the past year ; under class (*b*) ii an investigation is in progress in co-operation with the Vancouver Branch of the Forest Products Laboratories of Canada. Under class (*c*) a considerable volume of work has already been accomplished and the amount is rapidly increasing. With the provision, by 1931, of increased staff and accommodation under the new arrangements, it will be possible materially to accelerate the work. Details of the work already accomplished are given on pages 48 to 50.

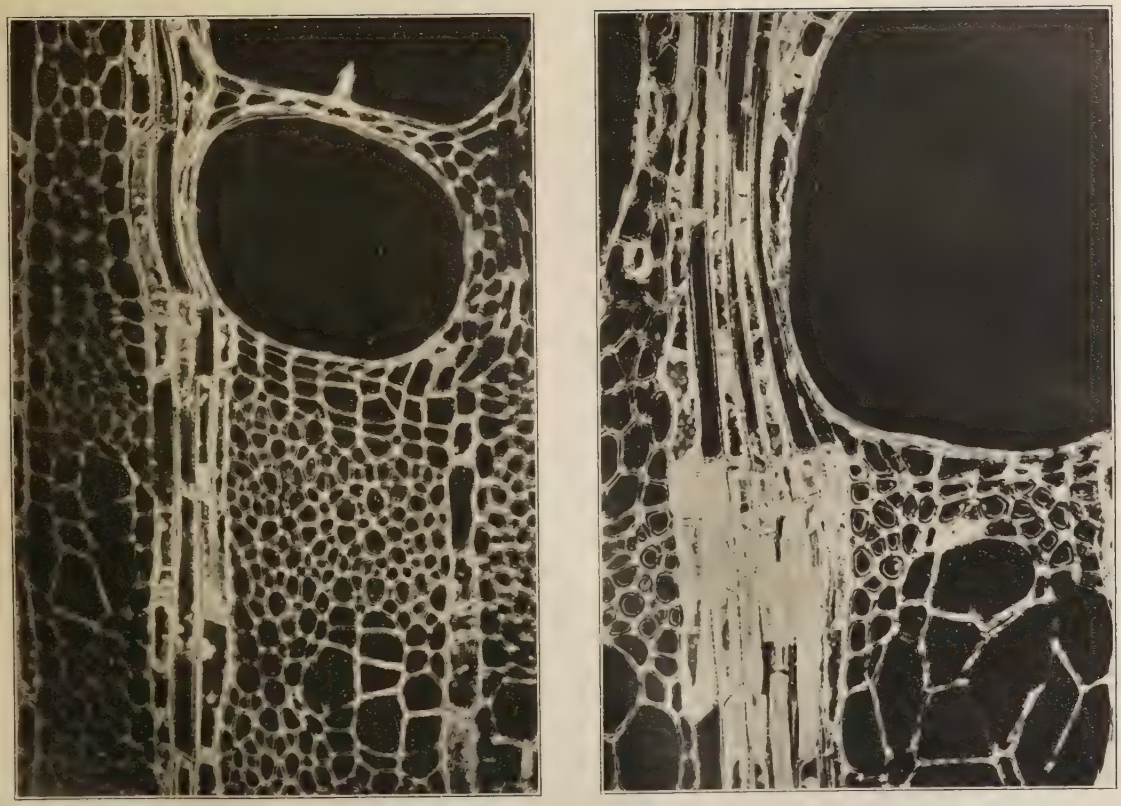
Choice of Empire Woods for Test

A word may here be said as to the class of Empire timber most likely to find an export market and repay testing. Tropical timbers may be broadly divided into two classes : hard, heavy, durable woods and soft, light, relatively perishable woods. The heavy class might find an export market either for special purposes where strength and durability are essential or where the timber is particularly attractive for decorative purposes ; but the great difficulty in finding export markets for these heavy timbers is that in many cases their excessive weight debars them from uses for which they are otherwise suitable. Turning to the light class, these woods have, with few exceptions, no potential value in the country of origin owing to their perishable character in tropical climates. On the other hand, provided they can be exported in a sound condition they may find a ready market, especially as many of them may be suitable substitutes for the



A B

FIG. 1. Transverse sections of common elm (*Ulmus campestris*), showing—
A. Youthful stage.
B. Adult stage. Mag. × 10.



A B

FIG. 2. Transverse sections of common elm (*Ulmus campestris*), showing- A. Youthful stage. B. Adult stage. Mag. × 250.

coniferous softwoods. Moreover, the cost of export is likely to be less for this class of timber than for the heavy woods. So far as the United Kingdom market is concerned, a frequent difficulty is to land the timber in this country at a competitive price. The two most promising openings in the United Kingdom are probably for a softwood substitute and for timbers that will help out the supply of ash.

II.—THE PROGRAMME OF RESEARCH

Variation in Wood Structure with Respect to Variation in Properties

The study of the variation in the properties of timber is a primary function of forest products research, and a knowledge of these variations, so far as they are due to the structure and composition of the wood, should be of value in two directions. In the first place, it should enable a more accurate preliminary estimation of the properties of wood to be made without recourse to empirical tests, and in the second place it should throw light on the complex relations existing between quality of timber and conditions of growth. The study of the anatomical structure of home-grown timbers and the relation of structure to physical properties forms the subject of an investigation which is being carried out by the Section of Wood Technology in conjunction with other Sections of the Laboratory. The properties which have so far received most attention are specific gravity and mechanical strength. The anatomical side of the work involves a detailed examination of a large number of samples representative of the wood in different parts of a tree, the samples being taken from the test specimens used for the determination of specific gravity and mechanical properties. Briefly, the examination covers the growth characteristics (as indicated by the growth rings), the size, nature and distribution of the constituent elements of the wood and the occurrence of anomalous structures.

The Anatomical Structure of Home-grown Timbers

A stage has now been completed in the study of the three most important species of elm grown in Great Britain, *Ulmus campestris* L., the common elm ; *Ulmus montana* Stokes, wych elm ; and *Ulmus major* Sm., Dutch elm. An account of the investigation and the conclusions reached is about to be published.[1]* The results of a critical investigation of this kind lead to a revised interpretation of certain generalizations, as for instance the rough-and-ready rule that the mechanical properties of a ring-porous wood, such as elm, are proportional to the percentage of summer wood. If this relation is examined in a large number of samples, the average of the results shows that the statement is approximately true, but that the deviation of any one sample from the mean is often so wide that it is quite impractical to regard the percentage of summerwood as an index of strength. The reason for this is to be found in the variation in the composition of the summerwood in different samples of the same species. In the case of elm (Figs. 1 and 2), the summerwood consists chiefly of alternating bands of thick-walled fibres and thin-walled vessels. Not only are the relative proportions of these two elements subject to considerable variation, but the composition of the fibres themselves is also variable. The fibre wall is usually made up of three layers, a thin primary wall, a thicker secondary wall, and a tertiary wall whose composition differs in important respects from that of the secondary wall. The tertiary wall has a gelatinous appearance and shows a preferential reaction to cellulose stains. It usually appears as a narrow but quite distinct lining to

* These numbers relate to the references at the end of each Section.

the fibre, but when it is well developed and thicker than usual, the secondary wall is correspondingly thin. As it is well known that the fibres are the elements which contribute most to the mechanical strength of the timber, it is not surprising that statistical analysis shows a positive correlation between strength and the proportion of fibres in the wood. The correlation is not close, however, and it is only when the tertiary wall is disregarded and the volume occupied by the primary and secondary fibre walls expressed as a percentage of the volume of the wood that a satisfactory correlation with strength is obtained. It is clear, therefore, that the composition of the fibre wall, in so far as it affects the strength of the timber, is more important than its actual volume.

The investigation of the anatomy of elm timber has been carried on concurrently with a similar study of English oak, which is also approaching completion. This forms part of a combined investigation into the properties and uses of the two main species of English oak, *Quercus robur* (*Q. pedunculata* Ehrh.), the pedunculate oak, and *Quercus sessiliflora* Salisb., the sessile oak. English oak is very variable in quality and there is no general agreement as to the relative merits of the two species. It may well be that the conditions under which the trees grow affect the character of the timber to a greater degree than any inherent differences between the two species. This aspect of the matter is being investigated.

Apart from the results obtained from these two investigations on elm and oak, the methods of technique evolved will incidentally prove of considerable value in their application to future work. The examination of the structural range in any one species is a time-consuming operation ; as such it cannot keep pace with the work of other Sections of the Laboratory, and it has therefore to be restricted to a limited number of species. As circumstances permit, it is proposed to continue this line of research on ash (*Fraxinus excelsior*) and one or more coniferous species.

The concomitant experiments, mentioned in our last Report, which are being made into the air-seasoning of oak grown under different soil and climatic conditions, have now been in progress for two years, and a similar period is required for their completion. It is hoped that these, together with the parallel investigations into the kiln-seasoning of the species, will give information leading to a comprehensive report on the seasoning properties of this refractory timber.

[1] Clarke, S. H. Home-grown Timbers. Their Anatomical Structure and its Relation to Physical Properties. Elm. *Forest Products Research Bulletin* No. 7. (*In the press.*)

Wood Technology and Silviculture

Instances have not been lacking in the past of the need for maintaining contact with silvicultural research. It will be of interest in this connexion to cite two examples of the way in which the work of the Laboratory is linked up with that of the Forestry Commission. The growth of Douglas fir was one of the subjects studied at Benmore, Argyllshire, during the annual excursion of the Society of Foresters of Great Britain, when the silvicultural treatment of plantations of this species was considered with reference to the quality of the timber produced.[1] The results of the Laboratory's tests on Benmore Douglas fir have shown that timber grown at a faster rate than six rings to the inch is unsuitable for general purposes. As a result of these findings, thinning operations may be modified so as to produce timber which conforms to these requirements.

The question of spacing or planting distance has also been discussed with officers of the Forestry Commission at a research conference held in London during November, 1929. It was generally considered that the factors of the locality probably exercise a

greater influence on quality than does the actual spacing, and for this reason no hard-and-fast rules for spacing can be laid down ; each site must be considered on its own merits. The influence of the site factor on the quality of timber is illustrated by the results of tests on two consignments of Corsican pine obtained from Knightswood in the New Forest and Holkham in Norfolk.[2] The striking difference between the mechanical properties of the timber from these two localities could not be explained on anatomical grounds ; it is likely that the variation is due rather to the chemical constitution of the wood substance being affected by differences in the quality of the soil on the two sites. Chemical analysis of wood of the two consignments is now being made.

[1] *Forestry*, 1929, **3** (2), 85.

[2] The Timber of Corsican Pine (*Pinus Laricio* Poiret) *Forest Products Research Bulletin No.* 6. H.M. Stationery Office, 1930. Price 2*s.* 6*d.* net.

Kiln-seasoning Properties of the Commoner Home-grown Timbers

Considerable progress has been made in the study of the kiln-drying of Corsican pine, Scots pine, European larch, Douglas fir, Black poplar and Common elm. While our investigations cannot be said to be finally complete in the case of any of these species, sufficient full-scale work has been done to show clearly how the timbers behave under kiln conditions, and, with the one exception of the elm, to establish suitable schedules for their treatment. Due to its tendency to " collapse " and to excessive warping when dried at kiln temperatures, further experiments on the kiln-drying of Common elm have been postponed until its behaviour when thoroughly air-dried has been determined. Some small-scale work has been carried out on the kiln-drying of sycamore and lime, but this must be regarded as of a preliminary nature leading to investigations to be made in the large kilns when opportunity permits.

Improvements in Seasoning Kilns and Methods of Test

The devising of new apparatus and modifications of existing kiln types is an important part of the Laboratory's work on seasoning.

Circulation tests have been carried out in all the large kilns and defects discovered have led to small improvements in design. The tests of the natural-draught kiln showed unexpected irregularities in circulation, which, if not of the greatest importance, were still sufficiently serious to justify attempts at their elimination. The work so far carried out has not been entirely successful in this object, but much knowledge of air movement has been gained, and it is hoped that alterations which have recently been made in the kiln will lead to substantially improved results.

A chart relating humidity to temperature and the depression of the wet bulb in the wet and dry bulb thermometer has been drawn, based on a formula which is appropriate to an air velocity past the wet bulb such as is likely to be found in any timber-drying kiln. This replaces an existing chart compiled some years ago from data applying to air velocities less suitable from the viewpoint of kiln work.

A simple means of measuring the volume of a wood sample for specific gravity determination by mercury displacement has been designed, which in use appears to give sufficiently consistent and accurate results comparing favourably with those resulting from methods already in use. Further tests of this instrument are, however, still being made.

Though intended solely for use in connexion with a special experimental grading system employed at the Laboratory and therefore having no great commercial interest, mention may be made of instruments for measuring the amount of cup, spring, bow and

twist and for measuring the shrinkage of a board while drying in a kiln, which have been designed and put into use.

Training of Kiln Operators for Industry

Arrangements have been made whereby commercial firms may send their representatives to the Laboratory to be trained in the operation of seasoning kilns and in carrying out the tests necessary during the kiln run. Nine such operators have so far attended for instruction, representing a steady, if by no means heavy, use of the facility.

Investigation of Air-Seasoning Methods

So far no systematic investigation of air-seasoning methods has been attempted, since it was beyond the compass of the Laboratory to undertake, in the initial period of its existence, the large amount of work involved in a study planned to deal adequately with even a few of the many variables involved. A scheme of work has now been prepared and means are being considered by which it may be put into at least partial operation during the ensuing year.

Comparison of Air-seasoning and Kiln-seasoning

It is of interest to know how the defects which develop during air-drying compare in amount and intensity with those resulting from kiln-drying, and opportunity is now being taken, whenever possible, of laying out for air-drying a number of boards of each timber used for kiln experiments. A special instance of this practice is that of Common elm, which, as already mentioned, suffered from severe distortion and from collapse when kiln-dried. Various methods of piling are being used in the air-drying of the timber, and preliminary treatments such as water-soaking and the girdling of the trees some years before felling are included in this particular test, which must take considerable time to complete.

Seasonal Variation in Moisture Content of Furniture Woods kept in Different Environments

It is well known that one of the chief advantages in the use of seasoned timber is its relative freedom from serious moisture changes and the accompanying variations in dimension. This stability is so important in the manufacture of furniture and decorative woodwork that the extent to which seasoning is carried out must in these cases be related as definitely and minutely as possible to those factors which are likely to affect the moisture content and dimensions of the timber during its period of service. A study, intended to discover the best degree of seasoning for various furniture woods and based on the investigation of their moisture contents under the conditions of atmospheric humidity met with at different times of the year and in different environments, such as in a centrally heated office, in a warmed living-room or in a bedroom, has now been completed after some two years' work.

The results show that moisture content to which timber should preferably be seasoned varies not only with the environment in which it is to be used, but also with the species, as can be seen from the following table :—

Species	Environment		
	Bedroom	Living Room	Office
Oak (American white)	13·6	12·8	12·5
Mahogany (Central American)	12·8	12·0	11·8
Scots pine	12·2	11·3	11·2

It will be seen that no great variation exists in the requirements for different kinds of furniture, and that the species is an even more important factor in the choice of the appropriate moisture content. The figures might perhaps be stated even more concisely :—

Oak	13 per cent.
Mahogany	$12\frac{1}{4}$ per cent.
Scots pine	$11\frac{1}{2}$ per cent.

SEASONAL VARIATION IN MOISTURE CONTENT OF TIMBER SAMPLES KEPT IN VARIOUS ENVIRONMENTS IN SOUTH FARNBOROUGH Nov 1926 to July 1927 LATER IN PRINCES RISBOROUGH.

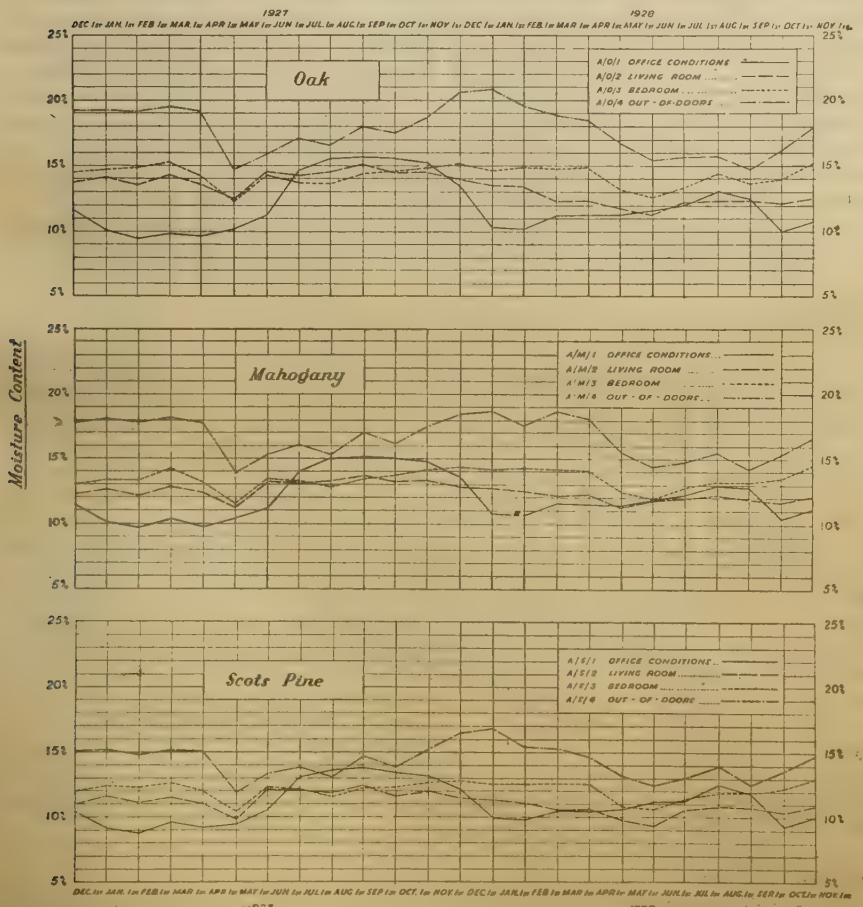


Fig. 3.

to apply generally to all classes of furniture manufactured on a production basis. On the other hand, considerable deviation from these figures may be necessary in special circumstances, when the conditions of manufacture are sufficient to warrant them—that is, when the furniture is of sufficient value to demand especial care in the preparation of its timber.

In the course of the experiment, a record of the seasonal moisture content variation which occurred in timber in different environments during 1928 and 1929 was taken for five different localities. The record taken at the Laboratory is shown in Fig. 3.

Of still greater importance, the approximate amounts of shrinkage and expansion which accompanied the moisture changes were also measured. Different means, such as polishing or painting the surface of the timber, by which the moisture and dimensional variations might be minimized were also investigated. Wax polishing applied to oak was found surprisingly ineffective, while french polish and enamel paint, though better, were less efficient than might have been expected. One way in which the dimensional variations in the width of a board can be reduced is by the use of quarter-sawn rather than plain-sawn timber. The investigation showed that this method is doubly effective. It is common knowledge that the proportion of shrinkage to decline in moisture content is considerably less for quarter-sawn material, but a further advantage appeared from the experiments in that the seasonal variation in moisture content was also found to be smaller. The full results have been embodied in a bulletin now in the press.[1]

[1] Stillwell, S. T. C. The Moisture Content of Wood with reference to Furniture Manufacture. *Forest Products Research Bulletin* No. 5. H.M. Stationery Office, 1929. Price 2s. net.

The Variation of the Moisture Content of Air-seasoned Timber with the Season

It is commonly believed that the longer timber is air-seasoned the drier it will become. For a certain initial period this will obviously be the case, and even over a more extended period it is so in a very limited sense. It is not entirely true, however, for after a certain stage is reached the progress of the drying is interrupted by the absorption of moisture by the timber from the relatively humid atmosphere of the winter months. This is illustrated in Fig. 4 by the record of the average moisture content of a number of sample pieces contained in a pile of Corsican pine boards. It will be seen that the timber was drier in September, 1928, than during the following six months. It was practically no drier in January, 1930, than in January, 1929, and at both these times it was considerably wetter than in September, 1928. From the point of view of the drying there was, therefore, practically nothing to gain in keeping the timber beyond September, 1928. In fact, with this species there was a definite disadvantage, for the high moisture content to which the timber came during winter laid it open to attack by fungi causing blue stain in the sapwood. By spring, the timber used in the experiment was sufficiently discoloured to reduce its original good appearance and value considerably.

The experiment is also of interest in showing the extreme rapidity with which the drying proceeded in the early stages, but it must be added that conditions were extremely favourable at the time. Similar rates of drying would not be expected in other species, and for some they would not be possible without serious damage from splitting and checking.

Shrinkage of Timber

It is well known that the amount of shrinkage which occurs during the seasoning of timber is variable and that among other things it is dependent on the manner of drying.

There is a simple explanation of why this should be, in that the surface of a piece of timber, which dries first, is restrained in its shrinkage by the wetter interior portion to an extent which considerably depends on the rate at which the two portions dry relative to one another. Generally, the surface dries without having experienced the full reduction in size which would have occurred in the absence of restraint. The surface becomes set and later, in its turn, tends to prevent the full normal shrinkage of the drying interior from taking place. It can be seen, therefore, that the final dimensions of the dried timber may well depend on the initial restraint of surface shrinkage and consequently on the rate of drying.

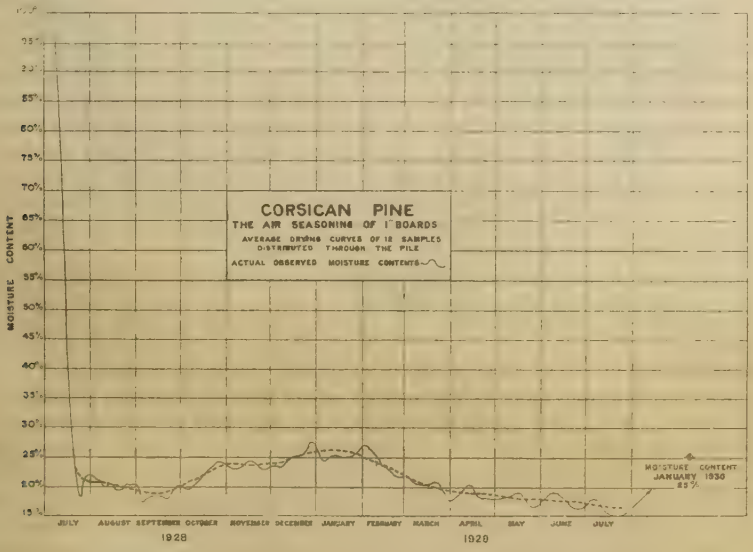

CORSICAN PINE
THE AIR SEASONING OF 1" BOARDS
AVERAGE DRYING CURVES OF 12 SAMPLES DISTRIBUTED THROUGH THE PILE
ACTUAL OBSERVED MOISTURE CONTENTS
MOISTURE CONTENT
MOISTURE CONTENT JANUARY 1930 25%
JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY
1928
1929

Fig. 4.—Air-seasoning of 1-in. boards of Corsican pine.

This explanation accounts satisfactorily for the smaller shrinkage which is found to occur in more rapidly dried timber, but it does not show why boards when dried under comparable conditions should shrink more at high than at low temperatures, as was found to be the case. In considering the effect of the initial drying conditions on shrinkage, the restraint of the shrinkage of the surface by the interior is often remembered, while the possible effects of the compression to which the interior is subjected is overlooked. If the centre portions are permanently compressible under the forces concerned in drying, this factor must have an influence on the effective restraint applied to the drier surface, and if the degree of compressibility is greater at higher temperatures, it is easy to see how greater shrinkages may occur under those conditions. The relatively great plasticity and compressibility of wood at sufficiently high temperatures is well known from the results obtained in steam-bending. In work carried out at the Laboratory, these properties have been found to exist also at lower temperatures, though to a lesser extent, and, throughout the range of temperature at which kiln-drying might normally proceed, timber has been found to be sufficiently compressible to affect shrinkage in an increasing degree as the temperature is higher.

In the course of studies made on shrinkage, another factor of some interest has been noticed. If a piece of green timber be heated under humidity conditions that allow no drying to take place, its dimensions alter and after cooling do not appear to return fully to their initial value. The change is a decided expansion tangentially in the direction of the annual rings, and a smaller but appreciable contraction radially, in the direction of the wood rays. The expansion which takes place in the tangential direction is illustrated in Fig. 5, which shows two adjoining thin cross-sections cut from a green beech log. The sections were first divided by a diametrical cut, and while the two pieces of one disc were heated at 100° C. in a saturated atmosphere, the others were allowed to season slowly. As is well known, due to the greater shrinkage in the tangential than the radial directions which occurs during drying, the effect seen in Fig. 5 A is produced, the two half-sections while meeting at their centre when placed together remain open at the circumference. After heating, although the disc actually lost weight during treatment, the reverse effect, seen in Fig. 5 B, of the sections touching at the circumference but open at the centre, was obtained. In the longitudinal direction the change is very small indeed, but appears, if anything, to be a contraction. It cannot yet be said that all species behave in this way, but all so far tested give similar results. The Laboratory's investigations also indicate that the amount of shrinkage may be influenced not only by drying stresses and by case-hardening, but by other factors involving the physical and chemical properties of the wood.

The variation of the amount of shrinkage according to the conditions of drying has an important bearing upon the present practice, common to the various Forest Products Laboratories, of determining certain properties of wood by calculations based on the dimensions of a specimen dried to constant weight in an oven at a temperature of approximately 100° C. It can be shown, for instance, that the shrinkage of a number of test samples when brought to oven-dry weight varies with the number placed in the oven at any one time. When the samples are numerous and their spacing close, the moisture given off causes higher humidities of the surrounding air and, hence, slower drying and greater shrinkage than when the samples are few and more widely spaced. The Timber Mechanics Section of this Laboratory has therefore discontinued the use of " oven-dry " dimensions in determining properties such as specific gravity, and uses instead " green volume " as a basis of calculations. Meanwhile, the possibilities of standardizing the drying method so that strictly comparable results may be obtained are being explored.

The Steam-bending of Timbers

Some of the recent work on the effect of temperature on the shrinkage and compressibility of wood serves also as a preliminary investigation into the factors which are involved in steam-bending, a study which it is proposed to take up on a larger and fuller scale during the next year.

Thermal Diffusivity

An experimental method for the measurement of thermal diffusivity has been devised and tested by making determinations on materials other than wood. There has been some difficulty in realising the conditions desired, as, for instance, in obtaining a sufficiently homogeneous material with a conductivity approximating to that of wood. Carefully dried sand, however, gave fairly consistent results. Good results have been obtained from the same test piece of timber, and while different pieces of the same species have not always yielded sufficiently close values, the divergence has always been such that it

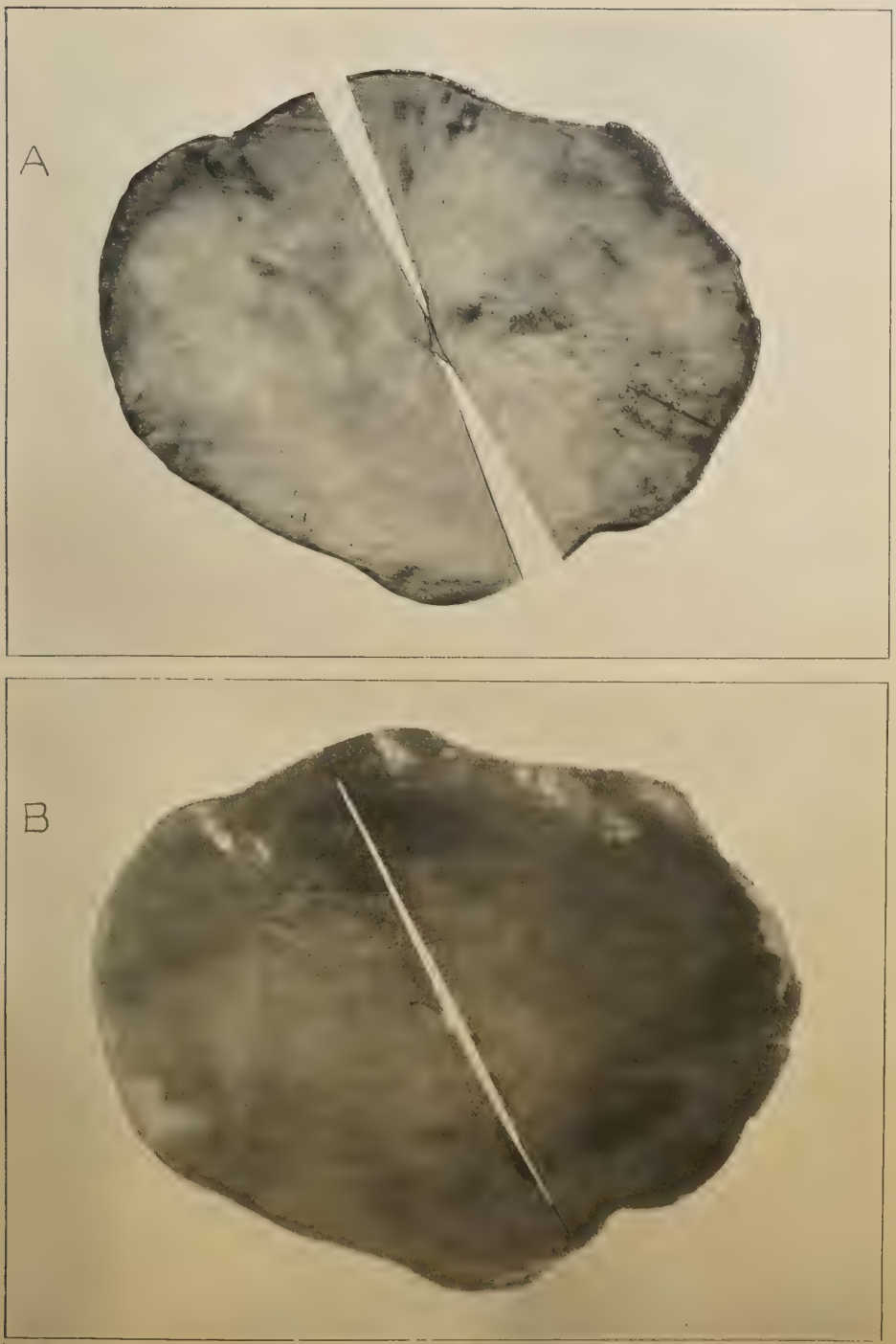


FIG. 5. Adjacent cross sections of a green beech log, showing tangential shrinkage (A) and expansion (B) as a result of drying and of heating at 100° C. in a saturated atmosphere respectively.

could probably be accounted by differences in the structure or in the moisture content of the various test samples. It is known that moisture content has so large an effect on the thermal conductivity that it will be necessary to adopt a standard moisture content in order that results may be comparable, and samples of various selected species are being seasoned with this in view. A simple apparatus for the measurement of the dielectric constant of moist wood has also been constructed.

The Effect of Kiln-seasoning upon the Strength of Timber

Tests to determine the relative strengths of kiln-seasoned and air-seasoned timber of the same species have been carried out upon carefully matched material prepared for the kiln-seasoning investigations. Ten species of home-grown timber have been tested in this way since the date of our last Report, the total number of mechanical tests being 5,737. The manner of conducting these comparative tests is generally as follows. One specimen plank is selected from each log, the total number of planks taken representing from 5 per cent. to 7 per cent. of the total number in the kiln load. Each plank to be used for the mechanical tests is divided into three approximately equal parts. One of these pieces is put in the kiln as part of the load, one part is tested as received in the green condition and the third part is put away to air-season. Matching the timber in this way for the three groups of tests—green, air-dried and kiln-dried—permits of very close comparison of the mechanical properties of the timber under the three conditions of seasoning.

The species thus tested and the districts from which the consignments have been taken are given in the following table :—

Species.	*Locality where grown.*
Oak (pedunculate) ..	Bedgebury, Kent ; Walcot, Shropshire.
Oak (sessile)	Walcot, Shropshire.
Beech	Blakeney Hill, Gloucestershire.
Dutch elm	Hinton, Dorsetshire.
Black poplar	Sutton Bridge, Lincolnshire.
European larch	Loch Tay, Perthshire.
Scots pine	Loch Tay, Perthshire.
Corsican pine	Knightswood, Hampshire ; Thoresby, Lincolnshire.
Norway spruce	Highclere, Hampshire.
Douglas fir	Benmore, Argyllshire.

Several of the consignments of these species have yet to be tested in the air-dried condition, as it takes considerably longer for the material to air-season than kiln-season. As a result of this, complete results have only been obtained for certain consignments of black poplar, beech, Scots pine and Douglas fir. For each of these four species a drying schedule has been found which preserves the strength value of the timber equal to that of the same timber dried under so-called natural conditions, i.e., air-seasoned. In fact, in some cases, even after allowing for the lower moisture content in the kiln-seasoned material, which naturally would be accompanied by greater strength, the mechanical properties have apparently been increased by the kiln treatment.

Strength of Kiln-seasoned Ash after subsequent Storage

Although it is shown that there is no basis for the allegation that kiln-drying, even when properly carried out, immediately injures the mechanical properties of timber, it is

sometimes stated that subsequent deterioration during storage will take place as a result of the treatment. The tests, described in the last Report, on kiln-seasoned ash with reference to this alleged deterioration have advanced another period of twelve months. The results over the past two years show that the strength of the timber, as indicated by the important properties in static bending, impact bending and compression parallel to the grain, has not diminished but to the contrary has increased. This increase may, however, be due to a further loss of moisture during the period the timber has been in storage, and the investigation is being continued.

The subject is, however, receiving attention from the chemical standpoint. The broad indications are that no distinct differences in composition are apparent between air-dried wood on the one hand, and properly kiln-dried wood on the other, and that therefore well regulated kiln-drying treatment of timber has no deleterious chemical effect. On the other hand, the results clearly indicate that if conditions in a kiln, or in the interior of the timber in a kiln, become so drastic as to approach the conditions obtaining in an oven-drying treatment, decomposition of the wood is to be expected. This all goes to show that kiln-drying is a highly technical process, requiring knowledge and experience. The majority of ill results are due to a neglect of this fact. It has been pointed out above that in the determination at the Laboratory of drying schedules appropriate to the different species, the results of routine mechanical tests of the material are a factor in framing the schedule.

With regard to the question of chemical changes due to drying, the results so far indicate in the case of oak wood that the drying of wood substance from the green condition—whether this be air-drying, kiln-drying or prolonged oven-drying at 105° C.—is accompanied by definite chemical changes in its major constituents. There are indications also, as noted elsewhere (page 43), that oven and kiln-drying produce chemical changes in the hemicelluloses of wood. Air and kiln-drying are associated with changes in the furfural-yielding complexes of wood substance to the extent that total pentosans are depleted while the lignin content and the pentosan content of the cellulose are enhanced. Prolonged oven-drying of green wood has been shown to result in an increase of lignin and a certain amount of hydrolysis of the carbohydrate components, which is more marked in the heartwood. The results of this investigation will shortly be published.[1]

[1] Campbell, W. G. and Booth, J. The Chemical Aspect of the Drying of Timber. (*In preparation.*)

The Mechanical and Physical Properties of Timbers

Fifteen consignments of home-grown timbers were collected for testing during the year. The species represented and the localities where the timber was grown are tabulated below :—

Species.	*From.*
Dutch elm	Watlington, Oxfordshire.
Wych elm	Needwood Forest, Staffordshire.
Black Italian poplar ..	Sutton Bridge, Lincolnshire.
Pedunculate oak ..	Bedgebury, Kent.
Scots pine	Walcot, Shropshire.
Silver fir	Walcot, Shropshire.
Sessile oak	Walcot, Shropshire.
Spanish chestnut ..	Delamere, Cheshire.

Species.	*From.*
Beech	Chenies, Buckinghamshire.
Beech	Brocklesby, Lincolnshire.
Sitka spruce	Highclere, Hampshire.
Norway spruce	Highclere, Hampshire.
Corsican pine	Thoresby, Lincolnshire.
Douglas fir	Loch Tay, Perthshire.
European larch	Glenfinart, Argyllshire.

Tests on air-seasoned material were carried out on fifteen consignments which represented the following :—

Species.	*From.*
Pedunculate oak ..	Wadhurst, Sussex.
Dutch elm	Wimborne, Dorsetshire.
Common elm	Wimborne, Dorsetshire.
Corsican pine	Knightswood, Hampshire.
Beech	Pigeon Green, Forest of Dean, Gloucestershire.
Common elm	Watlington, Oxfordshire.
Scots pine	Loch Tay, Perthshire.
Douglas fir	Loch Tay, Perthshire.
European larch	Glenfinart, Argyllshire.
Dutch elm	Wheatfield, Oxfordshire.
Wych elm	Needwood Forest, Staffordshire.
Black Italian poplar ..	Sutton Bridge, Lincolnshire.
Pedunculate oak ..	Bedgebury, Kent.
Scots pine	Walcot, Shropshire.
Spanish chestnut ..	Delamere, Cheshire.

The total number of mechanical tests which have been carried out on small clear specimens of timber in the green condition is 7,085 and the number of physical tests 10,226. In addition to these, air-dry clear material has provided 2,695 mechanical tests and 4,730 physical tests. Other tests on small clear specimens were carried out to provide data to determine the fibre saturation point of the material. These number 790 mechanical and 1,200 physical. The total number of tests on small, clear specimens of timber of all classes is 26,726. The results of the many tests on *clear material* of home-grown timber that had been completed up to June of this year are now compiled in a second progress report about to be published.[1]

[1] Chaplin, C. J. and Mooney, F. M. Tests on Home-grown Timbers in their Green and Seasoned Conditions. *Forest Products Research Project* 1, *Progress Report* 2. H.M. Stationery Office, 1929. Price 1*s*. net.

Tests of Dowelled Joints

Among the special tests that have been carried out may be mentioned a series of tests to compare the efficiency of furniture joints dowelled with beech. The dowels used in the joints were chosen from stock manufactured at home and abroad. The tests proved that, in spite of the opinion to the contrary held by some members of the furniture trade, the home product was quite equal to the imported material.

British Engineering Standard Specification for the Mechanical Testing of Small, Clear Specimens of Timber

It has already been reported that the Laboratory has been interested in the establishment of a British Engineering Standard for testing small, clear specimens of timber, and it is now gratifying to report that the specification was printed as standard in December, 1929. The first move towards this end was made early in 1927 when the British Engineering Standards Association was requested to form a committee to consider the question. A preliminary meeting was convened at the temporary Laboratory within the Royal Aircraft Establishment at Farnborough, and a decision was reached that such a standard was required, the Laboratory being thereafter represented on the main committee and on the sub-committee dealing with the specification. This specification includes all the tests, both mechanical and physical, as carried out in the Laboratory under Project 1, on small, clear specimens of timber, and also those mechanical tests which are required for clear material in aircraft construction.

Improvements in Apparatus for Mechanical Tests on Small, Clear Specimens

Some improvements in apparatus have been made during the past year. In co-operation with the Royal Aircraft Establishment, the Laboratory has produced a new design of the apparatus used in the shear-test in which roller-bearings have been introduced between the sliding-plate and the frame holding the specimen and also a device to retain the specimen in position without allowing it to bear against the sliding-plate, as was the case in the former design. By the use of this shear-block it has been possible to eliminate a large frictional force that was formerly latent and measured as part of the strength of the test piece. It is now evident from the results of tests with the new apparatus that this frictional error has amounted to approximately 20 per cent. of the load weighed by the testing machine. Further investigations are now in progress with this piece of apparatus to determine whether or not the apparent shear failure is due to a shearing force or if the failure is not perhaps to some large extent influenced by a cross-grain tension at the upper surface of the test piece.

The standard test for tension across the grain is also of uncertain value and this test is being explored to determine whether the results, when used for a comparison of species of timber subjected to a similar stress at points in structures where the timber is bolted or nailed, place the relative value of the timbers in the proper order.

Drawings were received from the Forest Research Institute, Dehra Dun, U.P., India, of a new type of supports for the specimens in the drop-hammer impact testing machine. A pair of these supports was ordered from an engineering firm in London, and has been in use for some months. It has been found that, although the modified design is not ideal, it is an improvement over the former design of supports and the results obtained from tests have been more consistent than they were formerly.

Timber Mechanics Committee

In the last Report, mention was made of certain tests such as those for shear and tension, referred to above, employed by the Forest Products Research Laboratories in the Empire and the United States of America which are open to criticism but which have been adopted at this Laboratory for comparative purposes until some better tests could be devised and introduced internationally. A further step towards the improvement of these tests has been made during the year by the formation of an expert committee to advise on these matters.

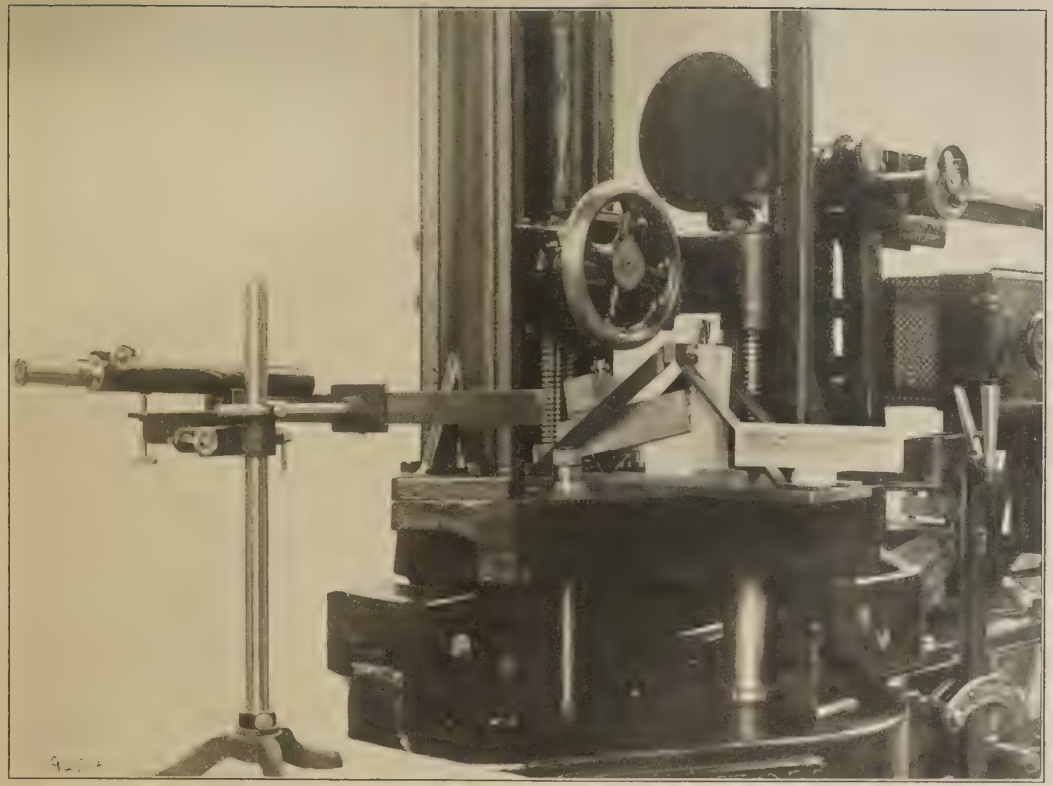


FIG. 6. Arrangement for a test of a dowel-joint as used in chair construction.

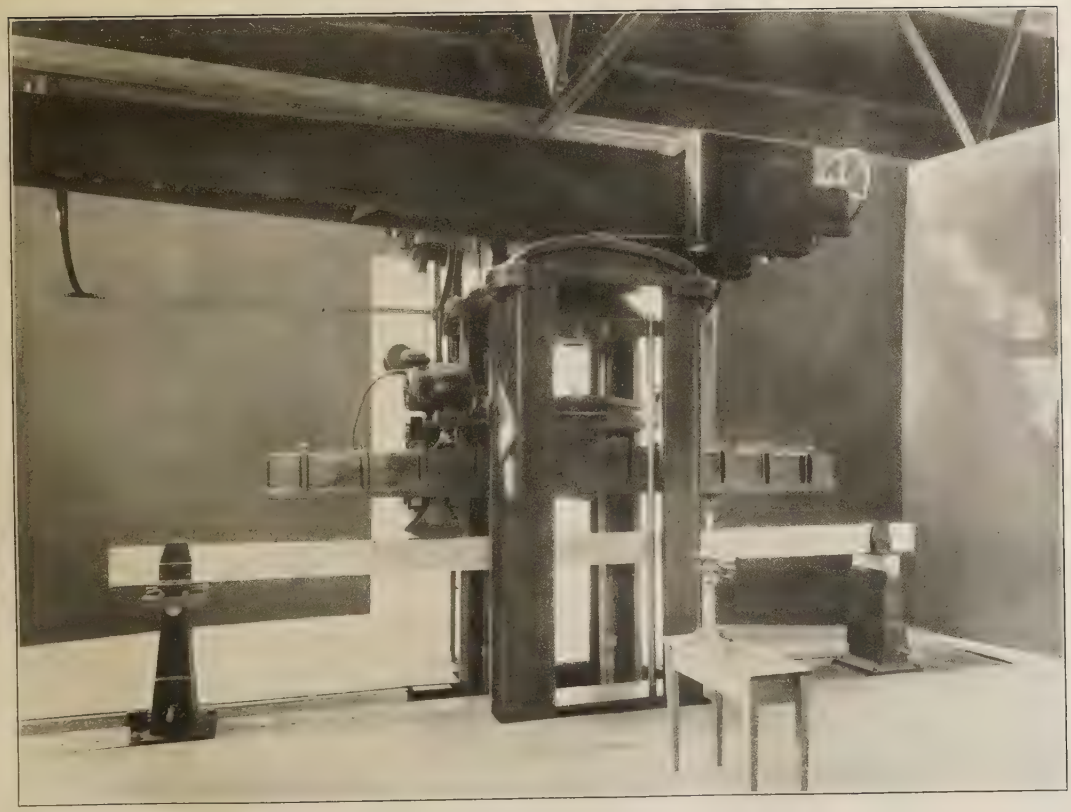


FIG. 7. A joist in position ready for a transverse bending test with four-point loading.

The first meeting of the committee took place on the 3rd December, 1929, at the Laboratory, when a full discussion of the several tests took place. It is gratifying to note that the committee has recorded their entire satisfaction with the manner in which the work is being carried out in the Laboratory. They have also agreed that the tests referred to above as being open to criticism should be continued until the methods have been thoroughly investigated. If investigation should disclose that the results of the tests do not indicate the true relative values of the species of timber for any definite purpose, efforts will be made to devise some other form of test which could be substituted as the international standard when the other Laboratories using the same methods have been convinced that an improvement in the tests in question is required. This indicates that when a test is found to be empirical but at the same time useful in distinguishing the relative values of species of timber for a given purpose, the test should be continued as a useful one for commercial practice ; and that a test which does not in all cases develop the true relationship between species of timber should be continued in parallel with any new test that may become an international standard. Moreover, the old form of test should be continued for a considerable period to give an over-lap, so that some idea may be formed of the relative values obtained by testing timbers under the old methods and under the new.

The second meeting of the committee was held on the 19th of December and a programme of investigations was drawn up. Some of the work connected with this programme deals with the analysis of data contained in past records of tests and this work is now going forward. Other parts of the programme deal with modifications in the apparatus used in the test and with variations in dimensions of the test pieces : these items will be taken up as soon as opportunity permits.

Other Laboratories, especially the United States Laboratory at Madison, Wisconsin, which is responsible for most of the preliminary work leading to present methods of timber testing, are to be asked to assist with any information or data that they may have on record so that no unnecessary duplication of research work will be undertaken. The Research Institute at Dehra Dun, U.P., India, is being called upon for information connected with the testing of timbers with interlocked grain, as this condition in the timber must influence the methods of testing for certain properties.

Testing of Timber in Structural Sizes

Decided progress has been made in the testing of structural timbers. A considerable quantity of imported material has been collected during the year and upon this tests have been going forward. The first consignment of this material was obtained at the Surrey Docks from a cargo from the Archangel district, and from it forty-two joists 9 inches by 3 inches and 14 feet long have been tested on a span of 12 feet.

The principle of four-point loading is used for these tests, the loads dividing the span into three equal parts with the middle part in a condition of uniform bending moment. The four-point loading attachment used in connexion with these transverse bending tests is the Laboratory's own design. This device has been manufactured by an engineering firm and is now in use in the Laboratory. A full description of it has appeared in *Engineering* in its issue of the 29th November, 1929. The device employs the principle of rectilinear arrangement of the three principal hinge points, namely, those at the centre under the cross-head of the machine and at each of the two loading-shoes which come in contact with the test piece. The loading shoes may be adjusted for lengths of the centre span under uniform bending moment of 2 feet to 10 feet. The action of this device in practice gives complete satisfaction.

The results of the tests are being subjected to a careful analysis in order to assess the relative influence of each knot or other serious defect in the timber. The outcome of this analysis finds application in the possible future establishment of a British code of grading rules for structural timber, with tables of relative safe working stresses. Minor mechanical tests to the number of 387 have also been carried out on the material from these structural timbers to determine the relative strength of the clear fibre as compared with that influenced by the presence of defects. Observations were also made of the growth features of the timber itself, so that the influence of rate of growth, density and summerwood may be determined. The physical determinations numbered 672.

Revision of existing Specifications for Building Timbers

In connexion with the testing of timber in structural sizes and the application of the results to the framing of specifications and grading rules, there may here be mentioned the conferences now in progress between a Sub-Committee of the Science Standing Committee of the Royal Institute of British Architects, representatives of the Timber Trades Federation of the United Kingdom, and of the Building Research Station and this Laboratory, for the purpose of revising existing specifications for building timbers. The use of out-of-date, indefinite specifications, calling for grades of timber not now obtainable owing to the changes in the conditions and the sources of timber supply, is a cause of confusion and trouble and the reform which the Conference hope to secure is a much needed one. The present Conference is exploratory, to secure the views of the interests concerned and gather data concerning existing conditions and needs. The British Engineering Standards Association may then be approached to set up a representative panel with the object of issuing an agreed standard specification. The Conference is in close touch with the Building Sub-Committee of the Interdepartmental Works Committee of the Admiralty, War Office, Air Ministry and H.M. Office of Works, and, as a basis for evolving a standard specification, has taken a comprehensive Government specification for timber now being revised by the Forest Products Research Laboratory in consultation with the Interdepartmental Works Committee. This revision is directed towards consolidating all departmental specifications, a consolidation which it will be seen has now a still wider application. The revision follows upon work that has already been carried out by the Laboratory for H.M. Office of Works, the Ministry of Health, the Air Ministry, and the Ministry of Home Affairs, Northern Ireland, in revising existing specifications and drawing up specifications for Empire timbers in view of the order that preference shall be given to these by all Departments of State. This revision and consolidation of Government specifications, with the work now being done by the Conference on general building and structural specifications, represents a notable advance.

Tests of Pit-props

A report is about to be issued describing the results of tests carried out over the past three years on the mechanical and seasoning qualities of certain home-grown species of timbers from different localities with respect to their use as pit-props. For comparative purposes a similar series of mechanical tests was made on imported Russian, Finnish, Swedish and French props. In all, 22 consignments totalling 380 props have been tested. The general results go to show that among home-grown timbers there is little to choose between Scots pine and Corsican pine as good timbers for props, provided they are not seasoned below 25 per cent. moisture content. Below this moisture condition the Corsican pine is inclined to be brittle. Douglas fir also appears to be satisfactory, as long as the rate of growth is not on the average greater than six annual rings to the inch radius. The tests on larch confirm the existing high reputation of this timber.

The results of the investigation make it clear that there is no foundation for the current opinion that the strength of home-grown timbers is inferior to that of imported timber of similar grade. This opinion is confirmed by the results of service trials under actual working conditions in a group of the South Wales Collieries. It should here be said that the efficiency of these trials, which were arranged through the co-operation of the Forestry Commission, was in no small measure due to the unsparing efforts of the Directors and officials of the collieries concerned. Apart from the question of price, due mainly to heavy cost of rail haulage, which may sometimes exclude the home-grown timber, these service trials and the accompanying laboratory tests show that from the standpoint of general suitability the home-grown timber should have no difficulty in successfully competing with foreign props and pit-wood. But it is essential that the home-grown timber be properly prepared for market. Past complaints on this score have not been wanting in justification.

A new branch of the investigation into the strength of mine timbers was commenced upon mining collars, a collar being the horizontal member which rests on props at the ends and supports the roof of the mine by its strength in transverse bending. The investigation into the strength of these mine collars began with the testing of imported collars of maritime pine. The consignment of maritime pine consisted of equal numbers of specimen collars from trees which had been bled for turpentine and those which had not been so treated. It is interesting to note that the collars from the bled trees were decidedly stronger than the others.

Prevention of Decay in Mine Timbers

Parallel to the investigation of the general suitability of home-grown timber for use as pit-props, an investigation into the preservation of mine timber has been begun. While the wastage of timber due to decay may not be so serious in the deeper and drier mines, it is certainly heavy in some of the shallow, damper mines. The annual timber bill of the mines in this country is considerable. Any prolongation of the effective "life" of the timber may therefore appreciably reduce consumption and by lowering the timber bill may assist towards cheapening the cost of coal production.

The first step was, as time allowed, to visit various mines in order to discover the extent of the decay, the general conditions inviting it, and the fungi chiefly responsible for the damage. In general, it may be stated that dry rot caused by *Merulius lacrymans* (the chief causal agent of dry rot in houses) or *Poria* spp. is common when the humidity of the air is high but where the timber is not soakingly wet nor the temperature above 75° F. In situations where the timber is appreciably wet, *Fomes annosus* is the chief cause of decay in softwoods and *Polystictus versicolor* in hardwoods, whilst, where the timber is in a water-logged state, *Armillarea mellea* (the Honey Fungus) causes damage to both. When the conditions are suitable, decay is very rapid and may necessitate the renewal of timbering in as short a period as six months.

The second stage is to be able to prescribe an effective preservative treatment, in which simplicity and cheapness are essential factors. Investigations at the Laboratory had already pointed to the appropriate treatment and it was decided that further investigation would best take the form of service tests in the mines themselves. Accordingly, the co-operation of the Mining Research Association was sought and experiments at one mine have already been begun. The antiseptics chosen are the cheaper inorganic salts, in preference to creosote, while the treatment will be carried out by the simple, "open tank" method. Four hundred treated props of Scots pine, treated with four different antiseptics, will be placed in the mine, with fifty untreated props to act as

controls. These will be examined at intervals, to obtain the relative durability of the treated over the untreated props. Careful records will be kept of costs.

Telegraph poles

An interesting investigation concerning the use of home-grown larch for telegraph poles was instituted during the year. This investigation was undertaken to discover means both whereby the seasoning of larch poles might be accomplished without producing the severe splitting which usually takes place and also whereby a sufficient quantity of creosote could be injected into this timber, which is notoriously difficult to impregnate. A very effective treatment by incising the surface of the poles at intervals has produced the desired results in both cases. In the case of seasoning, the shrinkage of a larch pole in seasoning is typically accompanied by relatively few but wide and deep fissures, often of considerable length. The incising process has the effect of distributing this checking due to shrinkage and causing it to assume the form of a larger number of unimportant, small checks over the surface, often following the lines of the incisions, instead of the usual severe splitting. In the case of creosoting, a better distribution of the creosote was obtained by the incising process, together with an increase of about 20 per cent. in the absorption.

The investigation also had regard to whether the poles should be seasoned barked or un-barked. Un-barked poles were found to dry very slowly; and since those which were peeled and incised dried quite satisfactorily, there is no doubt that any advantage in the condition of the un-barked poles when dry would be too slight to compensate for the extra time involved in their seasoning.

Mechanical tests have been carried out on poles as received without treatment, on seasoned poles both incised and unincised, and on creosoted poles both incised and unincised. These tests are now complete except for the poles which have been seasoned un-barked.

Material has been received from the Stores Department of the Post Office for an investigation into the relative strengths of fast-grown and slow-grown Scots pine telegraph poles with a view to determining the minimum rate of growth which should be specified when purchasing supplies.

A full report of the above investigation is in preparation.

Douglas Fir Railway Sleepers

In view of the difficulty experienced in this country of creosoting, even under pressure, the Douglas fir sleepers imported from British Columbia, and since it is often stated that only about half the amount of creosote can be injected into this timber as compared with the red deal commonly used, work has been planned with a view to demonstrating a method, which includes incision of the surfaces, whereby better results may be obtained. A quantity of representative sleepers to standard railway specifications have been obtained in readiness for the tests, which will shortly be begun.

Deterioration in the Strength of Timber at Various Stages of Decay

As mentioned in the last Report, an investigation was undertaken at the request of the Air Ministry into the deterioration and decay, during storage, of Canadian Sitka spruce for aircraft construction. The first results of the investigation were the identification of the fungus chiefly responsible for the damage as *Trametes serialis* Fr. and the proof that infection originated in Canada. Steps were therefore taken by the Air Ministry for a stringent selection of material in Canada. Arrangements were also made for the

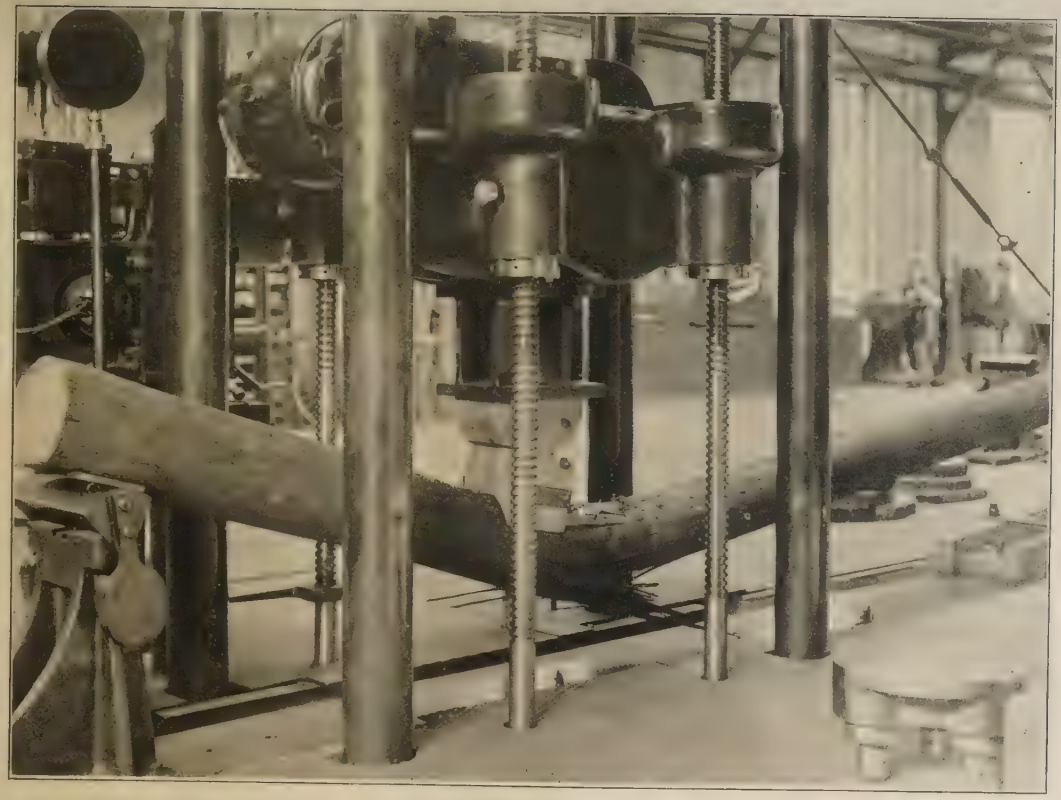


FIG. 8. Scots pine telegraph pole breaking under transverse bending test.

timber to be given an antiseptic brush treatment against infection during transport and special precautions were taken to ensure that the timber was stored and shipped under conditions which would not invite decay. The fungus concerned, *Trametes serialis*, is an active wood-destroyer capable, under optimum conditions, of causing the timber to lose up to 50 per cent. of its dry weight in under 8 months. The wood attacked becomes brittle and, when dry, splits into small, cubical portions as a result of cross-cracking. But little noticeable discoloration is caused during the early stages of its attack and therefore the incipient stages are difficult to detect. In fact, a new method of staining had to be developed, which has been described in the *Annals of Botany*.[1] The fungus is probably capable of withstanding considerable periods of desiccation, as thick-walled spores (chlamydospores) are formed in the tracheids of the summerwood.

It was intended to publish the report of this work during the current year, but publication was withheld in order to include some additional results. The report[2] will now be issued early in 1930, and will be complete so far as the original object of the investigation is concerned.

The results of the work have, however, led to investigations of wider scope and more general interest, and the defect of brittleness or "brashness" in timber is now being studied from several angles in a combined investigation by the Sections of Mycology, Chemistry and Timber Mechanics to discover the relationship between loss in mechanical strength and the degree of chemical decomposition observed at various stages of decay. The results when completed should indicate whether loss in mechanical strength is brought about gradually, as a result of the spread of decay throughout the wood, or whether a sudden failure in strength occurs when the wood reaches a definite stage of decomposition. This has naturally led to the question of the characterization of the chemical reactions attendant on the different types of fungal decay to which wood is subject. Attention has in the first instance been focused on the initial stages of decomposition and it has been shown that in its incidence decay of the "brown rot" type is equivalent in effect to mild aqueous acid hydrolysis.[3]

Investigation of the chemical reactions accompanying "white" rots is now in progress, and final results on the chemical side may well indicate new methods of preservation.

With regard to *Trametes serialis* Fr. and its effect on the cellulose of wood substance, additional experiments have now been made to ascertain whether this fungus is capable of living with cellulose as the one source of carbohydrate. An artificial medium consisting of a chemically pure cellulose prepared from Sitka spruce, together with the necessary nitrogenous and mineral constituents, was made up and inoculated with *Trametes serialis* and other fungi. All the fungi reputed to be cellulose destroyers made quite good growth on this medium, proving that they were capable of utilizing pure cellulose as a source of energy. Similar work was carried out using the hemi cellulose products from oak. Moderately good growth took place on hemi cellulose A, but growth on the hemi cellulose B was extremely poor, while residue from the preparation of these products proved definitely toxic. Differences were observable between the amount of growth on hemi cellulose A from green wood and on that from oven or kiln-dried wood, it being somewhat more vigorous on the product from the green wood.

A preliminary account of an investigation on the causes of brashness in ash caused by *Polyporus hispidus* (Bull.) Fr. has been published.[4] This work is now in abeyance,

as the investigator has resigned to take up an appointment at the Amani Research Institute, Tanganyika.

(1) CARTWRIGHT, K. St. G. A Satisfactory Method of Staining Fungal Mycelium in Wood Sections. *Ann. Bot.*, 1929, **43** (170).

(2) CARTWRIGHT, K. St. G. A Decay of Sitka Spruce Timber caused by *Trametes serialis* Fr. *Forest Products Research Bulletin* No. 4 (1929). (*In the press.*)

(3) CAMPBELL, W. G., and BOOTH, J. The Effect of Partial Decay on the Alkali Solubility of Wood. *Biochem. J.*, 1929, **23** (3), 566–725.

(4) NUTMAN, F. J. Studies of Wood-destroying Fungi. I. *Polyporus hispidus* Fr. *Ann. Applied Biol.*, 1929, **16** (1).

Standard Tests of Wood Preservatives

As was mentioned in the last Report, methods have been worked out whereby the toxic value of a preservative may be estimated by a laboratory test of comparatively short duration. These tests have been of two types: (i) the determination of the minimum concentration of the substance which will completely prevent the growth of a wood-destroying fungus in a nutritive agar medium, and (ii) the exposure to fungal attack of pieces of wood impregnated with the preservative in different concentrations, and the determination of the lowest concentration which will totally inhibit attack.

A number of these so-called "agar tests" have been carried out on certain standard and on several proprietary wood preservatives, using two different test fungi, namely, *Fomes annosus*, a fungus responsible for much damage in coal mines and used extensively for similar tests in the United States, and *Coniophora cerebella*, one of the dry-rot fungi, which has been used as a test fungus in the German work.

Two series of tests have been concluded, using the wood-block method. Ten weighed blocks of each of four species of wood were impregnated with six different concentrations of the antiseptics and these were then exposed to the attack of *Fomes annosus*, growing in specially designed flasks (see Fig. 9) for four months. At the end of this period they were examined and re-weighed and the loss in dry weight due to fungus action was determined. The results obtained show that this method will give a very good indication of the toxicity of any preservative under the given set of conditions. Certain modifications of procedure, such as the use of more than one test fungus, have been found advisable and these will be adopted in the carrying out of further tests. A visit by one of the staff of the Section of Mycology to the research laboratories of the Rütgers Company, Berlin (by courtesy of the Grubenholzimpraegnierung Company), provided an opportunity of studying the methods employed in Germany, where considerable attention has been paid to the scientific side of wood preservation. The methods of the Rütgers Laboratory proved to be essentially similar to those employed here.

The accompanying illustration (Fig. 10) shows a typical series of flasks containing wood blocks (Scots pine) impregnated with various concentrations of a toxic salt: it can be seen that no appreciable growth has occurred where the concentration of the salt solution was above 0·2 per cent.

In addition to the Laboratory tests for determining the value of various antiseptics, a comprehensive scheme of field tests is also in progress. Specimens are treated in different ways with various antiseptics and, together with untreated controls, are inserted in the ground as stakes. These specimens are inspected periodically and a record is kept of their durability. For each antiseptic tested three methods of treatment are employed, namely, heavy and light treatments in a pressure plant, and immersion in an open tank. To take into account the varying factors of soil and climate, parallel tests are to be carried out in three other localities in addition to Princes Risborough, where the tests are already

FIG. 10. Toxicity Tests. Series of 7 of the special culture flasks (for details of these see Fig. 9) containing Scots pine blocks, treated with various concentrations of a toxic salt, 4 months after inoculation with *Fomes annosus*. The good growth in the untreated control specimens to the right may be noticed.

FIG. 11. Field tests of wood preservatives.

in progress. Arrangements are now going forward, with the assistance of the Forestry Commission, for the selection of these other sites. On statistical considerations combined with consideration of the volume of work involved, the number of samples of each species to be treated with each of the preservatives chosen from time to time for test has been fixed at ten, with a similar number of untreated controls. Thus, using four species of wood, the combined total of the specimens concerned with the test of any one preservative at one of the localities selected for the test will be 240. The species of wood employed in the test are oak, beech, Scots pine and Douglas fir, respectively representing hardwoods and softwoods difficult and easy to treat. The main object of the project is a com-

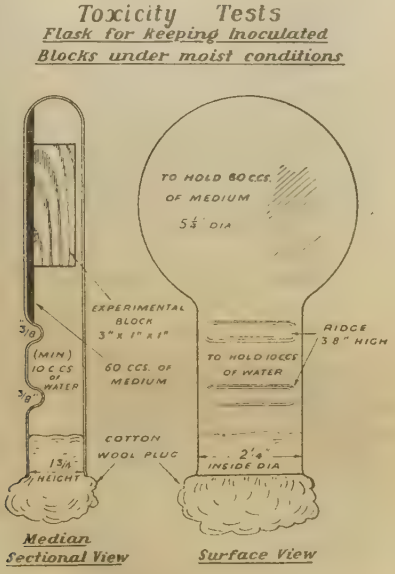


FIG. 9.

parative test of the antiseptic: the natural durability of the different species is not in question, the wood being regarded only as the medium for the test, so that a large number of species is unnecessary. The study of the natural durability of the different species forms the subject of a separate investigation, in which the timbers will be compared when used as fencing.

These field tests on preservatives will of necessity extend over a number of years before full results are available. In order to give a speedier practical test, on a scale midway between that of the laboratory and the field tests, a chamber is about to be constructed in which specimens similar to those of the field experiments can be placed under conditions most favourable to decay.

Owing to the long life of treated timber, reliable records of durability in situ are all too scarce. With the co-operation of private firms several records of the durability of treated timber for structural purposes are being kept. Advantage has also been taken of instances where treated timber has been used at the Laboratory to keep a record of its

treatment and durability. These include fencing posts, weather-boarding, structural timbers and platform timbers.

A patented process for preserving posts and poles already erected, by injecting them in situ with an antiseptic paste, has been investigated. A number of treated fence posts are under observation and the durability of these will determine the value of the process. The success of the process is to a large extent dependent on the diffusion of the preservative through the wood and preliminary tests have shown this to be quite satisfactory, although the durability tests will provide the final proof.

The Identification, Life History and Physiology of Wood-destroying Fungi

The success of advisory work in connexion with dry rot and other forms of decay largely depends upon the possession of a representative collection of type cultures of the different wood-destroying fungi, both for study and diagnosis. The Laboratory's collection, which contains 103 species belonging to 36 genera, is now fairly complete and includes the majority of the important timber-destroying fungi occurring in this country, besides a considerable number from America. It is still desired to obtain cultures of the more important fungi causing decay in tropical and other Empire and foreign timbers. The practical use of the type cultures has already been considerable and has allowed of rapid identification of the causes of decay in cases in which diagnosis would not otherwise have been possible. Two examples of the value of the collection may be quoted. In the first case, a fungus, found to be causing damage to fencing in the Sudan, had been isolated but could not be identified, as no fruiting body was present and no information as to the type of the rot was available. When a culture of this fungus was received, subcultures were made under the standard conditions and proved identical with those of *Lenzites thermophila* Falck in the collection, thus proving the identity of the fungus. The second case concerns the work, already mentioned, on the decay of Sitka spruce. In this case, the fungus, though isolated, could not be identified until finally a culture of *Trametes serialis* Fr. was obtained from the United States through the courtesy of Dr. A. Richards and proved identical with the fungus which had been isolated.

The fruit bodies which are formed in culture are frequently quite abnormal or abortive and unless they have been previously described may not be recognizable. A note describing the abnormal sporophores formed in culture by *Lenzites sæpiaria* (Wulf.) Fr. has been published.[1]

The value of the culture work in elucidating problems in the naming of obscure species is becoming increasingly apparent. As it appears that no two cultures of different species ever entirely agree, it will be seen that the position of allied species about which controversy exists may be determined by a study of their behaviour in culture ; as an instance of this may be cited the fact that *Poria vaporaria* (Pers.) Fr. and *Poria Vaillantii* (D.C.) Fr. give identical cultures, from which it may be concluded that these two species are one and the same and that the form differences on which their separation was based are due only to variation in environmental conditions.

Progress has been made in the systematic descriptions of the cultures and details of these are tabulated and filed together with other relevant facts about each fungus. Many cultures show differences visible to the naked eye, which enable them to be identified at once. A few examples are shown in Fig. 12. In others the microscopic characters have also to be examined. A number of species of *Fomes* and of *Poria* have thus been studied and it is intended that this work shall be continued in order to include all the more important species. Particular attention is being paid to those groups, such as the white species of *Polyporus*, which are extremely difficult to name and about

Schizophyllum Commune. Culture on malt agar. About three weeks old.

Pholiota Heteroclita Fr. Fruiting culture on malt agar. Two months old.

Trametes Rubescens 59, Fruiting culture on malt agar.

Paxillus Panuoides on acid malt agar.

Poria vaporaria culture on malt agar. About three weeks old.

Coniophora cerebella. Culture on malt agar. About three weeks old.

FIG. 12. Tubes containing pure cultures of wood-destroying fungi growing in a 2 per cent. Malt Extract Agar Medium. These show some of the distinctive types of growth by which fungi may be recognized in culture.

which there is disagreement among systematists. A study is also being made of the occurrence of secondary spores in the higher Basidiomycetes; these occur more frequently than has been supposed and are of importance, since, owing to their powers of resistance, they may enable the fungus to live through adverse conditions. Thus, longer periods of drought or high temperature will be necessary to sterilize wood in which they occur than in wood attacked by a fungus that does not produce such spores. A description of secondary spores occurring in culture of *Pholiota adiposa* Fr. has been published.[1]

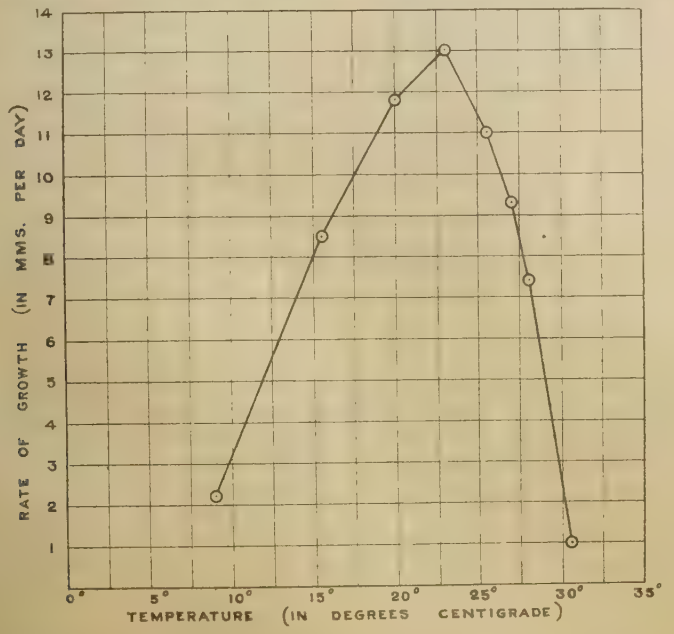


FIG. 13. *Fomes annosus.* Rate of growth at different temperatures.

The collection of microscopic slides showing sections of various timbers infected with different wood-destroying fungi has been considerably increased. The slides have been prepared from blocks of sterilized wood inoculated with a pure culture of fungus. These blocks are subsequently preserved as type specimens of the decay produced by that particular fungus species. In this connexion, as reported in another section (see page 29), a satisfactory and rapid method of staining the mycelium of fungi in wood has been developed and a description of the method has been published.[2]

The details of the fungus mycelium and its effect on the wood elements have been studied in a number of species and these are tabulated and filed together with the description of the cultures. Further additions have also been made to the collection of fruit bodies and of naturally produced rots.

Particular attention has been paid to the study of *Paxillus panuoides* Fr., a fungus causing a "brown rot" in coniferous timber. It is capable of causing considerable losses in dry weight, due apparently to the removal of cellulose, and it appears to be

chemically very active. Difficulty is experienced in making this fungus grow on a culture medium unless this is first acidified : this fact rather suggests that the fungus is secondary in its attack, following other fungi which produce acid in wood, and an experiment is in progress designed to determine whether this is the case.

Some work on the physiology of wood-destroying fungi has been carried out and the effect of temperature on their rate of growth has been determined for several species. The graph on page 33 shows the rate of growth in diameter in mm. per day of Petri dish cultures of *Fomes annosus* at various temperatures. These figures represent the average of ten plates, and measurements are taken daily over a period of several days. It will be noted that the graph shows an optimum temperature for growth at about 23° C., above which the rate of growth rapidly falls off and at 31° C. ceases entirely.

The temperature relations of all the more important species will be determined, since these data are not only in themselves of interest and practical value, but are often useful as means of identification ; for example, the high temperature required for the growth of *Lenzites thermophila* Falck. distinguishes it from other species of the same genus.

(1) Cartwright, K. St. G. Notes on Basidiomycetes Grown in Culture. *Trans. British Myc. Soc.* 1929, **14**, Parts III and IV.

(2) Cartwright, K. St. G. A Satisfactory Method of Staining Fungal Mycelium in Wood Sections, *Ann. Bot.* 1929, **43**, (170).

Lyctus Powder-post Beetles

The Laboratory has continued the inquiry, started in 1925, into the losses caused by *Lyctus* Powder-post beetles (family *Lyctidæ*) and into methods of preventing their increase. A full report has been published giving an account of the first two years' work.(1) It has been pointed out in this report that the spread of *Lyctus* beetles during the past few years has been largely due to the importation of American oak and ash already infested with these insects. As was expected, damage and loss have continued to increase still further and it has become evident that the problem of *Lyctus* control concerns not merely the furniture trade, on behalf of which the work was originally undertaken, but all industries which utilize hardwoods susceptible to attack, e.g., oak, ash, walnut, elm.

In the spring of 1926, the Laboratory carried out a preliminary survey of the conditions prevailing at the chief timber ports in this country with regard to the damage caused by insects, particularly *Lyctus*, in imported hardwoods. This work indicated that a thorough and extended survey was required, not only of timber ports, but of yards and premises of the trades concerned throughout the country. Such a survey was started in the spring of 1929 and is still in progress. It was felt that this work would be not only of the greatest value towards indicating the best lines upon which to develop the application of control methods, but would at the same time arouse the interest of the trades concerned and thereby assist in securing their co-operation in the application of these methods.

The main objects of the survey are to ascertain :—

1. To what extent *Lyctus*-infested timber is being imported into the United Kingdom.
2. The conditions prevailing in the storage grounds, yards and factories of hardwood-using industries throughout the country.
3. The attitude of the trades to *Lyctus* infestation and other insect damage to timber.

4. The methods of control in operation and the possibility of the trades modifying present methods of handling, sorting, &c., in order to reduce the loss caused by *Lyctus* beetles.
5. The occurrence of *Lyctus* in home-grown timbers.
6. The extent of damage in hardwoods caused by wood-boring insects other than *Lyctus*.

A preliminary tour of the districts to be included in the survey was made in February, 1929. Facilities were then obtained for inspection work and arrangements made with the secretaries of the various Timber and Furniture Trades' Associations in each district. In this way, it was possible to concentrate on inspection work during the six months when the insects are most active and when examination of timber for detecting the presence of live insects could therefore be carried out most easily and satisfactorily. During spring and summer, 1929, yards, factories, storage grounds or docks were visited in High Wycombe, Bristol and Avonmouth, Liverpool and North-East Lancashire, Nottingham, Manchester, Glasgow, Dundee, Edinburgh and Leith. During 1930, inspection of timber in the London district will form the major part of the work but, in addition, it is intended to include certain other centres throughout the country.

During inspection, notes were taken of the origin of all infested timber, the shipper's mark, the grade and size, the date of arrival at the quay or at the yard. Particulars were also taken as to whether firms possessed kilns, eliminated sapwood from finished articles or had experienced in the past any trouble with *Lyctus*. A large number of insects were collected, mounted on cards, identified and arranged in a survey collection which forms a permanent record of the species obtained during the survey. Specimens of various timbers showing different types of insect damage were also obtained and, where living larvæ were present, an attempt was made to rear the adult insects for purposes of identification. The survey work of 1929 has shown clearly that timber is imported into this country in an infested condition. Large quantities of American red and white oak were found to have been attacked before arrival in Great Britain ; recently imported Austrian oak was also frequently found to contain active *Lyctus* larvæ. The following is a list of the timbers recorded during the survey as infested with living *Lyctus* larvæ :—

Oak	English, American, European, Japanese.
Ash	American.
Elm	English.
Walnut	English, French, American.
Hickory	American.
Silky Oak	Australian.

Lyctus linearis Goeze and *Lyctus brunneus* Steph. have been found abundantly in home-grown timbers, the former species also occurring frequently in imported European oak. *L. planicollis* Le C. (see Fig. 14) and *L. parallelopipedus* Melsh. were found only in American oak and ash. *Lyctus brunneus* was never taken in recently imported timber from the U.S.A., whilst *L. linearis* was taken only once ; both species, however, are abundant and widely distributed in the United States.

In addition to the collection of data on the abundance of *Lyctus* throughout the country, much useful information has been obtained with regard to other insect damage to timber, especially that caused by Pin-hole borers (families *Scolytidæ* and *Platypodidæ*). A full account of the results obtained during the survey will, in due course, be published and will describe the conditions found throughout the United Kingdom with regard to insect attack in hardwood timbers, with special reference to *Lyctus* Powder-post beetles.

Control Measures.—The Laboratory's work during the past four years has shown that a great deal could be done to prevent the spread of *Lyctus* in this country by the simple means of inspection of timber, if all concerned—importers, merchants and manufacturers—would realize their individual responsibility in restricting the spread and increase of a pest that is responsible for so much damage. The Laboratory has attempted to bring home this aspect of the problem to the trades concerned by delivering lectures during the past year at the invitation of the Trade Associations in London, Manchester and High Wycombe.[2] Although, due to increase of damage from *Lyctus*, there are indications that much greater interest is now being taken individually by the various industries, it still remains for these industries to co-operate in a widespread campaign for the elimination of this pest. The situation is, however, encouraging. In several individual cases, firms have adopted adequate control measures in their own yards; while an important Trade Federation is now planning concerted measures by all its members.

In the case of manufacturers possessing seasoning kilns, a simple means of steam sterilization of *Lyctus*-infested timber has been determined and is described in detail in *Forest Products Research Bulletin* No. 2.[1 and 3] It is of interest to note that such treatment has been adopted by several firms and has proved of practical value. At the same time, it must be recalled that this method of *Lyctus* control requires a kiln in which a temperature of 130° F. and relative humidity of 100 per cent. can be reached and maintained for a period of several hours. The Laboratory's previous work in this respect has indicated that, provided due time is allowed for all parts of the timber undergoing treatment to reach the required conditions of temperature and humidity, these conditions possibly need not be as high as 130° F. and 100 per cent. humidity. Furthermore, it is not always desirable or convenient to hold timber at such conditions, nor may the type of kiln possessed by many manufacturers permit of these being attained and held for the required time. For these reasons, it was decided to ascertain whether lower conditions of temperature and humidity combined with longer periods of exposure would not also prove lethal to *Lyctus* beetles, larvæ and eggs. Work has therefore been proceeding in this direction and it appears that a temperature of 125° F. with 80 per cent. humidity may prove sufficient to kill the insect, provided the infested timber is treated over a requisite period which has not yet been finally determined.

Such a sterilization treatment does not, however, render the timber immune from re-infestation. The Laboratory has therefore complementary work in progress to devise some practical and economic means of rendering sterilized or other timbers free from attack (see page 42). In this connexion also the Laboratory has carried out a number of minor tests with wood treated by Mr. H. G. H. Kearns of Bristol University.

[1] Fisher, R. C. *Lyctus* Powder-post Beetles. *Forest Products Research Bulletin* No. 2. H.M. Stationery Office, 1929. Price 3*s.* net.

[2] Fisher, R. C. *Lyctus* Beetles and Other Insects Injurious to Timber. *Timber Trade Lectures*, 1928–29, pp. 46–55. Ernest Benn, Ltd., London. Price 5*s.* net.

[3] Stillwell, S. T. C. Heat Sterilization of Timber in Relation to Kiln-seasoning. Note 1 in *Forest Products Research Bulletin* No. 2.

Susceptibility of Timbers to Lyctus Attack

Time has been devoted to studies in the Laboratory of the various *Lyctus* species found in this country, particularly with regard to the susceptibility of various timbers to attack. In the first Report of the Forest Products Research Board, it was stated that apparently the size of the pores of a timber as compared with the maximum width of the

egg of *Lyctus brunneus* determined whether or not a species is liable to attack by this insect.[1] It has now been possible to make a series of measurements of the eggs of *L. parallelopipedus*, *L. planicollis* and *L. linearis*. This study is therefore being continued and data are being collected from a number of infection experiments. In addition, it has been possible to obtain from Mr. I. H. Boas of the Australian Forest Products Laboratory a supply of certain Australian timbers which are being utilized in a series of experiments on this subject. The *Lyctus* beetles are of importance in Australia, where many species of timber are liable to infestation by them. It is hoped that the results of the work with Australian woods, when compared with data given by Australian workers,[2] will provide useful information on the relation of *Lyctus* beetles to the timbers they attack. The information so far collected by the Laboratory on the susceptibility of timbers to *Lyctus* attack has already proved of use in connexion with a request from a firm to suggest timbers for caskage which would not be attacked by these insects, in substitution for timbers found to be susceptible.

[1] Clarke, S. H. On the Relationship between Vessel Size and Liability to Attack by *Lyctus*. *Forestry* 1928, **2** (1), 46.

[2] Roughley and Welch. Wood Borers Damaging Timber in Australia. *Bulletin No.* 8, 1923. Technological Museum, Sydney.

Furniture Beetles

The Laboratory has continued its studies of the life history of the two Furniture beetles (family *Anobiidæ*) especially concerned in this country with damage to old furniture or to structural timbers—*Anobium punctatum* de G., the Common Furniture beetle, and *Xestobium rufo-villosum* de G., the Death-watch beetle. It has been felt necessary to concentrate on the biology of the two insects rather than on empirical investigations on the efficiency of antiseptics and insecticides for their control. With increased knowledge of the rate of development of these beetles and the conditions in wood which invite attack, means of preventing damage or of restricting the increase of the insects will be facilitated. Before studies of any insect can be carried out satisfactorily large stocks of the species concerned must be obtained and adult beetles be available in quantity for experimental work. During the past year, the stocks of *Anobium* and *Xestobium* have been substantially increased, but even now sufficient material has not been collected.

Anobium punctatum, the Common Furniture Beetle

The study of the life-cycle and habits of *Anobium punctatum* (see Fig. 15) has been continued, and special attention given to the rate of development of the larvæ. It has frequently been stated that normally the life-cycle of the Common Furniture beetle covers one year. Experiments have shown, however, that the duration of the life-cycle under Laboratory conditions may extend over a period of more than two years. Larvæ which emerged from eggs in August, 1927, have not yet completed their development, $2\frac{1}{2}$ years later. There is evidence to show that the progress of attack depends not only upon the nature of the wood in which the insects are feeding, but also on conditions of temperature and humidity. Further studies are in progress to determine the relation between moisture content, age and other conditions in wood, and its suitability for the development of *Anobium*. In this connexion, work has also been continued on the possible relation of the presence of fungus and susceptibility of timbers to attack by this insect (see also below).

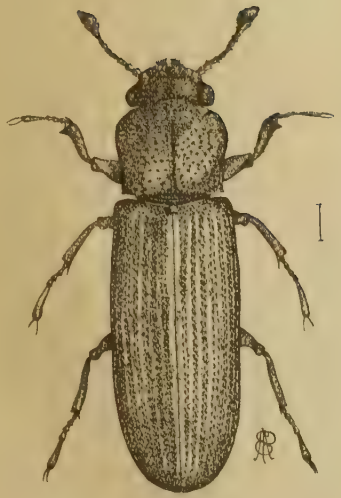


FIG. 14. Powder-post Beetle.
(*Lyctus planicallis* le C.)

FIG. 15. Common Furniture Beetle.
(*Anobium punctatum* de G.)

FIG. 16. Death-watch Beetle.
(*Xestobium rufo-villosum* de G.)

Xestobium rufo-villosum, the Death-watch Beetle (see Fig. 16)

The work on the Death-watch beetle has already established some interesting facts with regard to its habits and rate of development. No difficulty has been experienced in obtaining *Xestobium* eggs in the Laboratory. Willow, oak, pine and spruce were used for egg-laying experiments with this insect, but a distinct preference was shown for willow, though eggs were also obtained on the other timbers. It has been shown that conditions of temperature and humidity have a direct influence on the duration of the egg stage of *Xestobium*, which may vary from two up to six weeks or even longer according to the conditions under which the eggs have been kept. General observations have been made on the habits of newly emerged *Xestobium* larvæ and interesting facts established with regard to the early stages of attack. For example, the death rate of newly emerged larvæ is extremely high and this, doubtless, has a direct bearing on the slow progress of attack by *Xestobium* in buildings. Work is in progress to ascertain the optimum conditions of temperature and humidity for the development of this insect. There are already indications that a high moisture content of timber may be necessary in the early larval stages to enable the larvæ to commence boring. Although the results so far obtained in this direction are not yet conclusive, they are of special interest and indicate in what direction future work must be developed. They are also of importance when it is recalled that the progress of Death-watch beetle attack in buildings is often associated by architects and builders with insufficient ventilation and with " built-in " timbers, e.g., wall plates. A detailed study of the conditions of temperature and humidity in roofing timbers where *Xestobium* is actively working is required as one of the next steps in the Laboratory's work on this insect. Such work is now being arranged and facilities obtained for taking the necessary records in the roof of a suitable building. In this connexion, it is also intended to attempt to reproduce the conditions under which *Xestobium* occurs, in the roof of a special house shortly to be erected at the Laboratory for experimental work on dry rot and the Death-watch beetle. The object of such a building is to provide a structure which can be infested with fungus or insect, and in which methods of prevention and control can be tried out. Furthermore, in the case of the Death-watch beetle, life-history studies of this insect will be facilitated by ready access to a building in which experimental work can be carried out as desired. Work of this kind cannot be undertaken in the roof of a building, at a distance from the Laboratory, where, even if facilities were available, only occasional visits could be made. It has been found extremely difficult to reproduce in the Laboratory the conditions under which *Xestobium* occurs in roofing timbers. For these reasons, the existence at the Laboratory of a suitable building for this work will enable more rapid progress to be made in acquiring a knowledge of the habits of the insects under conditions similar to those under which they cause such serious damage.

The relation of fungus in timber to attack by *Xestobium* or other wood-boring beetles is also receiving attention. It was stated in our first Report that wherever timber was found to contain active Death-watch beetles, fungus was also present. Samples of wood attacked by *Anobium* and by *Lyctus* have now been examined and in every case fungus mycelium has been found present in the neighbourhood of the insects' tunnels. Cultures have been made from a number of these samples and the fungi obtained can be classed under the general term of " mould." They are of the type commonly found growing on timber and none of them is of the wood-destroying type, neither does it appear that any definite species of fungus can be associated with any one genus or species of beetle. A number of samples of willow and oak have been inoculated with fungi isolated from

Xestobium-attacked specimens, and then utilized in a series of *Xestobium*-infection experiments in the Laboratory. It has been shown by Buchner (1928)[1] that association of wood-boring insects with fungi may be far more general than hitherto supposed. He has drawn attention to the presence of yeast cells in special appendages of the mid-gut and female reproductive system of the *Anobiidæ* and other wood-boring insects. It appears that these yeast cells are in some way associated with the ability of the insects to derive nourishment from such a medium as wood, and it is essential to attempt to ascertain the part played by such yeast cells in the development of the insect. Dissections have therefore been made of adults and larvæ of *Xestobium* and *Anobium* and yeasts have been isolated. It is proposed to attempt to grow these on a cellulose medium in order to ascertain whether they are capable of breaking it down and thus possibly making it available for the beetle larvæ.

Meanwhile, by comparison of chemical analyses of attacked and unattacked portions of wood (oak) infested with *Lyctus* or *Xestobium*, an attempt is being made to throw further light on the source from which these insects derive their nourishment. This work is being carried out by the Chemistry Section of the Laboratory. Both *Lyctus* and *Xestobium* attack oak, but have never been found together; the larvæ of the Powder-post beetle attack only the sapwood during seasoning or shortly after this process has been completed: the larvæ of the Death-watch beetle, on the other hand, cannot develop until the wood has "aged" and until some change, chemical or physical, has taken place. Information, however, is lacking as to what constitutes the food of both insects. The chemical investigation has yielded interesting results, upon which a report is in course of publication.[2] The indications are that Powder-post beetle larvæ do not utilize the cell-wall substance of wood as food. They would appear rather to abstract nourishment from within the cells of oak sapwood. Death-watch beetle larvæ, on the other hand, are responsible—possibly in symbiotic association with micro-organisms—for the decomposition of the wood in which they bore. Attack is apparently focused on the carbohydrate components of wood substance. Further work is in progress to test the validity of these preliminary findings.

(1) Buchner, P. *Holznahrung und Symbiose*. Julius Springer, Berlin. (1928.)

(2) Campbell, W. G. The Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles, *Lyctus* spp. and *Xestobium* sp. *Biochem. J.* 1929, **23**, (6), 1290–3.

Sirex, Wood Wasps (Siricidæ) and Fungus Association

A study of the association of fungus with wood wasps of the family *Siricidæ* has been continued in co-operation with Dr. R. N. Chrystal, Entomologist, Imperial Forestry Institute, Oxford. Buchner (1928)[1] has described the presence of glands containing fungus, at the base of the ovipositor in several species of *Siricidæ*. This work has been undertaken to determine the significance of these glands and the role played by the fungus in the physiology of the insects.

Material was first received in April, 1928, and a note giving a summary of progress was read at a meeting of the Association of Economic Biologists in October, 1928.[2] The three members of the *Siricidæ* which have so far been available for study have been *Sirex cyaneus*, *Sirex gigas* and *Xiphidria dromedarius* (?), the first two occurring on *Larix* and other conifers, and the last on *Salix*.

FIG. 17. Death-watch Beetles (*Xestobium rufo-villosum*). Mag. > 2½ (approx.).

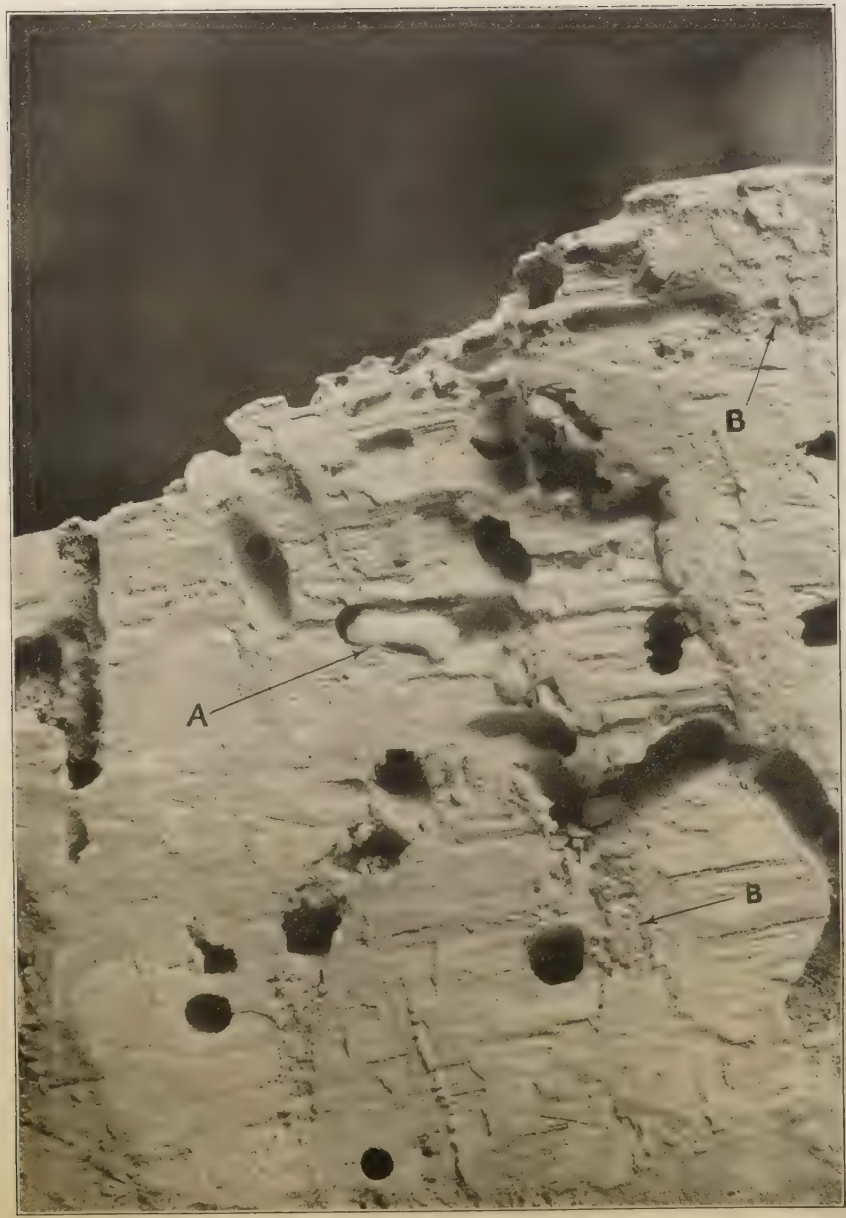


FIG. 18. Section of portion of oak beam attacked by Death-watch Beetle. Mag. × 2½ (approx.).
Note.—A. Larva in tunnel (bore dust dislodged in cutting section).
B. Bun-shaped pellets, characteristic of bore dust of Death-watch Beetle.

Sirex cyaneus.—The investigation has been concentrated principally on this species and the results so far obtained are as follows :—

1. Pure fungus cultures have been isolated from :—
   (*a*) The glands at the base of the ovipositor.
   (*b*) Eggs removed from the vagina.

   Note.—No fungus was obtained from eggs removed from the ovaries.

   (*c*) Eggs extracted from oviposition tunnels.
   (*d*) Larval tunnels at different stages.

   Identical cultures have been obtained in every case from material received from three widely separated counties.
2. Eggs taken from the vagina and examined microscopically show either short segments of hyphæ (oidia) adhering to their walls or a fine weft of fungus mycelium investing their walls.
3. Sections across oviposition tunnels taken at different times, from immediately after oviposition up to the hatching of the larvæ (four to five weeks) show a progressive increase in fungus development with the egg as the centre of infection. Directly after oviposition the fungus is confined to the egg wall, whereas after four to five weeks, when the young larvæ have just emerged, the hyphæ are seen to have penetrated the wood elements on all sides of the tunnel. Sections of the wood, taken from the samples on which oviposition has occurred but not across the tunnels, showed no fungus if taken in the early stages.
4. A study has been made of the growth of the fungus on malt agar and it has been identified as belonging to the *Thelephoraceæ*, probably a *Stereum* sp. Work is being continued with a view to ascertaining at what stage in the life history of the insect the glands are formed and the manner in which the fungus gets into the glands. Sterilized wood has been inoculated with the fungus and young larvæ introduced into holes made in the wood. Controls have been set up by putting larvæ into similar blocks of wood which had been previously sterilized and were free from fungus.

Sirex gigas.—Results with this species are as follows :—

1. Pure fungus cultures have been isolated from :—
   (*a*) Larval tunnels.
   (*b*) Glands at base of ovipositor.
2. Identification. The fungus is a member of the *Thelephoraceæ* and is in all probability *Stereum sanguinolentum.*

Xiphidria dromedarius (*?*) :—

1. Eggs have been examined and a weft of mycelium observed investing their walls.
2. Cultures have been obtained from larval tunnels.
3. Identification. The cultures have fruited in culture and the fungus is a *Stereum* sp. These fructifications have been submitted to Kew for identification.

General Summary of Results.—It is seen, therefore, that all the species of *Siricidæ* so far examined contain fungus in glands which are situated at the base of the ovipositor.

The insects definitely inoculate the wood during oviposition with the fungus and the fungi so far isolated have all belonged to the same group, namely, the *Thelephoraceæ*. These fungi appear in every case to belong to the genus *Stereum*, and in the case of *S. cyaneus*, at any rate, the fungus appears to be specific to the insect. It will probably be found to be true for the other species that a specific fungus is associated with each, but in these other cases material has been examined up to date from only one source.

(1) Buchner, P. *Holznahrung und Symbiose.* Julius Springer. Berlin. (1928.)
- Cartwright, K. St. G. Notes on a Fungus Association with *Sirex cyaneus*. *Ann. Applied Biol.*, 1929, **16** (1), 182–187.

Standard Tests of Antiseptics for the Prevention of Insect Attack

Parallel to the investigations for determining the comparative values of various antiseptics for protecting timber from fungal decay, a series of specimens of oak, treated by the full-cell process with zinc chloride and another preservative, at different concentrations, have been exposed, together with untreated controls, to *Lyctus* attack. All the specimens contained a proportion of sapwood, which alone is attacked by this insect. As mentioned above, a steaming treatment has been devised for sterilizing *Lyctus*-infested timber, and information is required as to a suitable and economic means of preventing *Lyctus* attack in sterilized timber. It is intended eventually to utilize the furniture beetles also in such tests, but meanwhile this cannot be undertaken satisfactorily until Laboratory technique for rearing these insects is perfected. The results of the tests at present in progress will serve as standards with which other preservatives may be compared.

Two series of experiments are in progress : (1) in which treated samples and controls, 6 in. by 4 in. by 1¼ in., have been exposed to *Lyctus* attack in specially constructed cages, and (2) in which small sections of sapwood only, 1½ in. by 1 in. by ½ in., have been cut from the larger standard-size specimens, exposed in boxes to *Lyctus*, and detailed observations made on the progress of infestation. It was reasonable to assume that the treatment to which the larger specimens had been submitted was sufficient to ensure complete penetration of the sapwood at least. While the results of the first series of experiments are not yet available, interesting information has been obtained from examination of the small samples. This may be summarized briefly as follows :—

It is already apparent that zinc chloride solutions in concentrations varying from 0·1 per cent. to 2 per cent. prevent neither egg-laying of *Lyctus* nor the hatching of the egg and initial feeding of the larvæ. Although, ultimately, larvæ feeding in oak treated with the above range of concentrations of zinc chloride have died, yet it is of interest to note that when the concentration was 0·2 per cent. some larvæ fed for three months before being killed ; where the concentration was 2 per cent. it was possible for a larva to feed and survive for approximately one month.

In the case of the second salt tested (a proprietary article), although egg-laying was not prevented by any of the concentrations used (0·05 per cent. to 1 per cent.), fertile eggs did not hatch in samples treated with solutions of concentrations higher than 0·2 per cent. Even at lower concentrations, also, numbers of eggs were destroyed, but instances were recorded of larvæ emerging and beginning to tunnel in the treated samples. The maximum period during which a larva survived and fed was one month in a sample treated with a solution of concentration only 0·05 per cent.

Inquiries concerning Insecticides

The Laboratory is frequently asked to advise on the value of proprietary insecticides or to suggest a suitable treatment for timbers attacked by the Death-watch beetle (*Xestobium rufo-villosum*) or other injurious insects. The work so far undertaken, referred to in our first Report, indicates that one of the essential properties required, if an insecticide is to be of use against wood-boring insects, is the power to penetrate the wood to as great a depth as possible. This degree of penetration is of special importance when the treatment of timber infested by *Xestobium* is contemplated. The greatest difficulty in choosing a suitable material is not that of finding a substance toxic to the insect in its various stages, but of combining this toxicity with adequate penetration. It appears from the work so far carried out that the most satisfactory substances yet known are mixtures containing certain chlorinated hydrocarbon compounds, of which there are some good proprietary preparations on the market.

It has been the policy of the Laboratory to concentrate rather on biological studies of the insect concerned, with the view to determining means of prevention as a result of increased knowledge of the conditions which render timber susceptible to infestation by wood-boring insects. Meanwhile, insufficient is known of the life-cycle and habits of the furniture beetles, including *Xestobium*, to carry out really satisfactory tests with insecticides upon timbers attacked by these insects. A number of preliminary tests of a purely empirical nature have been made at the Laboratory with various preparations pending the acquisition of large stocks of the insects concerned, and of new data upon their rate of development and habits, which, in time, will enable more satisfactory tests to be conducted. Nevertheless, where a firm desires to have tests carried out with a proprietary insecticide suitable for the destruction of wood-boring insects, arrangements can be made as opportunity affords to carry out, on payment of a fee, such tests as are at present possible.

The Hemicelluloses of Wood

The study of the chemistry of the hemicelluloses of wood has been continued, and it has been shown that these substances bear some relationship to lignin and that possibly they are transition products in the elaboration of that substance in nature. In addition, though no structural differences are apparent between the green and oven or kiln-dried wood of English oak, comparative investigations of the hemicelluloses from green and dried wood respectively indicate that these substances undergo some chemical change as a direct result of the drying treatments referred to, in view of the fact that yields from oven and kiln-dried wood are always approximately 50 per cent. lower than those previously obtained from green and air-dried wood. Further evidence of a definite effect of oven and kiln-drying on hemicellulose is reflected in the fact that, while the fungi *Merulius lacrymans* and *Coniophora cerebella* grow vigorously on the product from green oak wood, the growth of the same fungi on the product from kiln and oven-dried wood is much less vigorous.

The Relations of Lignin and Cellulose

An investigation of the degradation of wood by simultaneous action of ethyl alcohol and hydrochloric acid has just been completed. It has been shown that the extract obtained from wood after treatment with acid-alcohol solutions under various conditions is invariably derived from portions of all the main constituents, so that the precipitate obtained on neutralization which has been termed "alcoholysis lignin" by Holmberg and Runius may reasonably contain material derived from wood constituents other

than lignin. The influence of alcohol on the course of the acid hydrolysis of wood is discussed in detail, and experimental evidence is cited in favour of the view that the association of the lignin and cellulose in wood is of a physical rather than a chemical nature.

[1] Campbell, W. G. The Degradation of Wood by Simultaneous Action of Ethyl Alcohol and Hydrochloric Acid. *Biochem. J.*, 1929, **23** (6), 1225.
[2] Holmberg and Runius. *Svensk. Kem. Tidskr.*, 1925, **37**, 189.

The Wood-working and Finishing Qualities of Wood

The qualities of the different timbers are dependent on the anatomical structure of the species and may be broadly classified under weight, appearance, mechanical and seasoning qualities, durability and wood-working qualities. Research in timber has generally been directed by Forest Products Research Laboratories towards determining all but the last, and it is only of recent years that working qualities have received the attention they deserve. Definite information on this subject is often as important as data on strength, seasoning qualities and durability, in determining the possible uses to which a new timber may be put.

The difficulty of such work is that the personal factor must necessarily arise in such cases where tests cannot be carried out on a purely mechanical basis, as in any machining processes involving hand feed. Further, in nearly all instances the record of results must depend to a greater or less extent on the opinion of the operator. The Laboratory has drawn up a working plan, which is now on trial, under which each timber the working qualities of which are unknown will be subject to standard tests arranged as far as possible so as to eliminate the personal factor. The basis for comparison of soft woods has been taken as red deal (Scots pine, *Pinus sylvestris* L.) : for hardwoods, beech (*Fagus sylvatica* L.). In certain cases it has been necessary to devise special measuring machines, as for instance in determining the relative smoothness to which different woods can be worked on a planing machine.

The study of these qualities has become of increasing importance with the development of wood-working machinery within recent years, since the standard of accuracy in machining has steadily improved.

A number of preliminary tests have been made on home-grown timbers such as oak, beech, Scots pine, Corsican pine and Douglas fir. These have further indicated the desirability of having a uniform method of comparing the working properties of timbers with some consideration of the power consumption.

Charcoal-making in Portable Kilns

It was mentioned in the first Report that investigations were in progress on charcoal-making in portable kilns. These experiments relate to the utilization of waste from the forest and mill and to the production by means of charcoal of suction gas as a propellant in place of petrol for motor vehicles and stationary engines. In this country, the primary interest lies in the possibility of a profitable outlet for waste wood—the ever-pressing problem of the mill and factory—were the market for charcoal to undergo a substantial increase. The Empire overseas, equally concerned with this problem, is also interested in the development of the portable kiln and in suction gas as a substitute for petrol, especially with regard to those districts where haulage leads are long and petrol expensive. The large number of inquiries from all parts of the Empire testify to the interest aroused.

In considering this type of charcoal kiln, the essential features are efficient carbonization of various classes of waste timber varying in moisture content, and, if possible, sufficient lightness in weight to facilitate carrying from place to place where this would have to be done by manual labour. If such a kiln can be devised, strictly portable and easy to erect and dismantle, it will materially reduce the cost incurred by the transport of timber to a fixed kiln.

In these metal kilns, it has been found possible to manufacture the stick or lump charcoal virtually irrespective of weather conditions. Moreover, the charcoal can be produced free from dust, pebbles, and uncarbonized vegetable matter, as contrasted with what often occurs during carbonization by the usual hearth or turf-burning method. Another and very important feature of the metal portable kiln, provided it is possible so to arrange the construction that the joints are quite air-tight, is that the use of water is rendered unnecessary: the old-fashioned turf kiln requires large quantities of water for extinguishing purposes. This requirement often influences the site of the earth kiln or alternatively involves carrying the water by hand or by ditch to the site.

Experiments were first of all made with three types of kilns, with a view to the production of good quality charcoal from various species of wood. It was found that a considerable amount of difficulty arose in producing a uniform grade of charcoal in that the carbonization varied according to the species used, the moisture content of the timber, the method of ignition, and in the regulation of air supply and so forth. The difficulties have been overcome: an indication of the character of the charcoal now produced is the regularity with which it has been purchased by the wood distillation industry. It was also desirable to regulate the times of lighting and the general conduct of carbonization so that the necessity for supervision during the night should be eliminated as far as possible, this being an important consideration, at least in this country, in manufacturing the charcoal in the forest. After various manipulations and modifications in the kilns themselves, it was eventually found possible to eliminate night attention entirely for two of the kilns and almost entirely for the third type.

An attempt is now being made to evolve a better type of kiln which will be easily portable and quickly erected and dismantled, and a kiln has been built of sections differing —for comparative purposes—in gauge, style of stiffening and method of jointing. Some experience has already been gained in the operation of this kiln and further modifications are in hand.

As a possible development of the market for wood charcoal, some experiments of a preliminary character have been made to gauge the effect of air-activation with regulated temperatures, upon hardwood charcoal carbonized in these portable metal kilns.

III.—ADVISORY WORK

General Utilization

It was mentioned in the first Report that the Section of Utilization is the link with industry in building up cordial relations, carrying out commercial surveys to find out trade difficulties and indicate lines of research, in keeping research work practical, and in getting the best value for the cost of research by securing the application of the results. In addition to the work of this Section in the revision of timber specifications, charcoal-making, and industrial surveys, many hundreds of inquiries have been dealt with covering the utilization of timber in all its forms and uses from the conversion of the log in the forest or sawmill to the remunerative disposal of sawdust and shavings. As an indication of the variety and range of these may be cited requests concerning the

choice of timbers for various purposes, whether for construction, utility, decoration, box-making, veneers, flooring, railway sleepers, rollers, caskage, handles, and bending; and questions directed towards finding new uses for timbers. A very large volume of work has fallen to the Section of Utilization in consequence of the activity of the Empire Marketing Board in their work on behalf of Empire timbers at the various exhibitions throughout the country.

The success of this Section has been most gratifying.

Identification of Timbers

A marked increase in advisory work in respect of the identification of timbers has to be recorded. In this connexion, there is no need to enlarge upon the necessity for the authoritative identification of timbers, based on a study of authentic type specimens, for there is abundant evidence of the confusion produced in the wood using industries on the one hand by the multiplicity of names applied to the same timber, and on the other hand by the application of the names of well-known woods to inferior kinds of timber.

As one illustration of the confusion attending the lack of standard trade names may be cited the case of a firm who were unable to obtain a certain timber because it was known to them under an unusual name. When the identity of the wood had been established, there was no difficulty in putting them in touch with a source of supply. The question of standardizing trade names received the attention of the Imperial Forestry Conference of 1928. Following the recommendations of the Conference, a committee sitting under the auspices of the Empire Forestry Association, and including representatives of the Laboratory, has drawn up a Standard List of names for Empire Timbers which should prove of value to the timber trade no less than to the forestry profession.

Partly with the aim of assisting timber users in confirming the identity of the timbers they are handling, a Bulletin[1] on the structure and identification of British Hardwoods has been produced in conjunction with the Imperial Forestry Institute. In preparing the text, care was taken to present the subject-matter in such a form that it could be used by people previously unacquainted with the technical terminology. The Bulletin contains descriptions of the more common British-grown hardwoods with photographs illustrating the structure of the wood as seen under an ordinary hand lens.

[1] Chalk, L. and Rendle, B. J. British Hardwoods. Their Structure and Identification. *Forest Products Research Bulletin No. 3*, 1929. H.M. Stationery Office. Price 5*s.* net.

Seasoning

As already mentioned, inquiries respecting the design of seasoning kilns and about other matters connected with seasoning have shown a marked increase, and there is no doubt that the work of the Laboratory in this direction is making its influence felt. Not a few of the inquiries arose as a direct result of the Laboratory's publications on seasoning or of assistance previously given to other firms, while several inquiries came from abroad.

Timber Mechanics

The advisory work done by the Section of Timber Mechanics has largely consisted of supplying information on the comparative strength of less well-known timbers which it is desired to substitute for timbers in familiar use, especially with regard to the substitution of foreign timbers by those of home or Empire origin. Other subjects of advice have been concerned with abnormal behaviour with reference to some strength property, and with the drawing up of specifications. The results already obtained from the

mechanical testing of home-grown timbers have afforded information of value to the Forestry Commission concerning the most advantageous rate of growth with respect to strength, as in the case of Douglas fir to which reference is made on page 14.

Dry Rot and other Questions concerning Mycology

The identification of dry rot and measures for its control have been the subjects of a largely increased number of inquiries during the period under review. The inquiries covered a wide field and included questions of decay or deterioration in railway sleepers, poles, pit props, flooring, paving, shuttle blocks, oak desks, and so forth. A number of visits have been paid to examine buildings suspected to be suffering from dry rot and reports submitted on their condition. The causes of staining in various timbers, particularly in oak, have also been the subject of several inquiries.

Damage by Wood-destroying Beetles

Another section in which the advisory work has increased greatly during the past year is that of Entomology. Over one hundred inquiries have been dealt with in this period. The majority of the inquiries have concerned *Lyctus*, *Xestobium* and *Anobium*, and have been received from timber importers and merchants, manufacturers, builders and architects, as well as private individuals. Inquiries received from H.M. Office of Works, concerning insect injury to timber, have also been dealt with by the Laboratory.

Representation on Outside Committees

The Laboratory is represented on the following Committees :—

Standing Committee on Empire Forestry. (*Representative :* Director of Research.)

Empire Forestry Association—Standard names for Timbers—Sub-committee. (*Representative :* Director of Research.)

British Engineering Standards Association—

Building Industry Committee. (*Representative :* Officer in Charge, Utilization.)

Revision of Aircraft Timbers Specifications. (*Representatives :* Officers in Charge, Timber Mechanics and Seasoning.)

Aircraft Technical Committee AC 2 on Timber, Glue and Casein Cement. (*Representatives :* Officers in Charge, Timber Mechanics and Seasoning.)

Standardization of the methods of testing small, clear specimens of Timber. (*Representatives :* Director of Research, and Officer in Charge, Timber Mechanics.)

Empire Marketing Board—

Empire Timbers Publicity Committee. (*Representative :* Officer in Charge, Utilization.)

Imperial Institute—

Advisory Committee on Timbers. (*Representative :* Officer in Charge, Utilization.)

War Office—Interdepartmental Works Committee—

Sub-Committee on Building Materials. (*Representative :* Officer in Charge, Utilization.)

IV.—WORK FOR OTHER PARTS OF THE EMPIRE

Co-operation with Vancouver Forest Products Laboratory

A co-operative investigation has been undertaken with the Vancouver Branch of the Forest Products Laboratories of Canada with the view to determining the conditions under which timber should be shipped to avoid decay and undue change of moisture during the ocean passage. So far, portions of two cargoes loaded under known conditions in Vancouver have been examined on their arrival in this country by representatives of the Mycology and Seasoning staff of the Laboratory. This work is expected to continue and should lead to recommendations of practical value.

Assistance to other Forest Products Laboratories

The Laboratory was able to assist the Government of the Federated Malay States in securing the equipment for their new timber mechanics laboratory. Various specifications and tenders were forwarded to the Laboratory through the Crown Agents for the Colonies and were carefully scrutinized and returned to the Crown Agents with recommendations for purchase. In some cases, this entailed suggestions for the modification of the design of some of the machines and the inspection of the results of calibration trials on some of the instruments.

The summer-wood estimator which had been designed and patented by this Laboratory has proved very useful in service and the Australian Government has asked for an instrument to be constructed for their Laboratory. Various instruments designed by the Laboratory for measuring seasoning defects (see page 15) have also been supplied.

The Forest Products Laboratory of New Zealand has also requested assistance in obtaining an impact-testing machine. This machine is now in the course of construction.

Testing of Empire Timbers

Mechanical tests were carried out on the following species of Empire timbers :—

1. Sapodilla, *Achras Sapota* L.—British Honduras.
2. Glassywood, *Guettarda* sp.—British Honduras.
3. Wattle, *Acacia mollissima*.—Natal.
4. Musharage, *Olea hochstetteri*.—Kenya Colony.
5. Danta, *Cistanthera papaverifera*.—Gold Coast.
6. Hendui, *Lophira procera*.—West Africa.

1. *Sapodilla*.—Two sets of tests were carried out, the first on material converted and tested under the standard tests for small, clear specimens. Half of the material was tested green with the full range of tests, the other half was tested air-dry under tests of impact bending, hardness and cleavage. The second set of tests was carried out on small specimens (1 in. by 1 in.) and confined to compression parallel to grain and toughness. These were tested green and kiln-dried, and some air-dry specimens are still to be tested. The wood was found to be generally strong, tough and dense. Its shrinkage was high, but this was to be expected in view of the density.

2. *Glassywood*.—Standard tests on small, clear specimens were carried out with a full range of tests both green and air-dried. A second series of tests on smaller specimens (1 in. by 1 in.) was carried out for compression parallel to grain and toughness, green and kiln-dried. The wood was found to be not nearly so strong as Sapodilla, but is of fair average strength with a comparatively high value for compression parallel to grain.

3. *Wattle.*—Two consignments were tested, Consignment 1 received in August, 1927, Consignment 2 in April, 1928. Consignment 1 when green was cut into 2 in. by 2 in. and 2 in. by 1½ in. sticks and tested with a full range of standard tests. The air-dry material was cut into 2 in. by 1½ in. and 1 in. by 1½ in. sticks and tested under static and impact bending, compression parallel to grain, hardness, shear and cleavage. Consignment 2 was treated similarly when green, but the kiln-dried material was converted to 1 in. by 1 in. compression parallel specimens, and the air-dried to 2 in. by 2 in., 1½ in. by 2 in., and 1½ in. by 1½ in. specimens and tested under static bending, compression parallel to grain, perpendicular to grain, and hardness. The material was found to have mechanical properties somewhat similar to home-grown ash, but was harder and stronger.

4. *Musharage.*—Four consignments of this timber were tested, two in accordance with the standard tests for small, clear specimens of timber and two with smaller test pieces of about 1-in. square section. Of the two consignments tested under the standard tests, one was tested green only and under static bending, impact bending, compression parallel to grain, hardness and cleavage, and the other consignment was tested green, kiln-dried and air-dried; under the first two conditions the tests were similar to those named above, while the air-dry material was tested under similar tests except that there was insufficient material to test under impact bending. The two small consignments from which test pieces 1 in. by 1 in. were cut were tested green, kiln-dried and air-dried, in compression parallel to grain and toughness. The timber was found to be somewhat lighter than Glassywood, slightly stronger in impact bending, and having similar mechanical characteristics under the other tests.

5. *Danta.*—Tests on this timber were carried out in co-operation with the Imperial Institute. A log was received and converted into the standard 2¼ in. by 2¼ in. sticks, and a portion of this material was tested under the standard test for small, clear specimens of timber with a full range of tests. A number of sticks were selected and stored to air-season, and when the moisture content was reduced to the standard condition of 12 per cent., test pieces were cut for impact bending only. The wood was found to be hard and tough, and to have a high value in shock-resisting property.

6. *Hendui.*—The material was received in a converted condition and it was found that its moisture content was definitely below its probable fibre saturation point. The consignment was of poor quality. It was cut into standard sticks and tested with a full range of tests. The timber was found to be extremely heavy and to have corresponding high strength properties quite equal to the best teak from Burma as tested at the Laboratory at Dehra Dun. Comparing this timber with teak its hardness is twice as great, and also its strength in shear, while its strength in tension across the grain is three times the similar mechanical property in teak.

Preliminary experiments in seasoning were made in the Laboratory's small kilns on Musharage, Glassywood, Sapodilla and Black Wattle. So far as seasoning is concerned, all these timbers have shown sufficient promise to justify further investigation on a more commercial scale. Musharage has, indeed, been dried with success in a large kiln and a schedule for its treatment is thus known, though further investigation might be made with advantage.

It is interesting to mention that, while the Black Wattle seasoned both rapidly and well in the controlled atmosphere of the kiln, it was found to split and check with considerable freedom when exposed in a green state to normal summer atmospheric conditions.

Advisory Work for the Empire

In addition to advisory work at home, much has also been undertaken for the Empire overseas, including India (charcoal and various), Burma (shunting poles and hammer handles for British railways), Australasia (uses, markets, charcoaling, caskage, timbers for bending, organization of forest products research), British Honduras (uses, markets, designs and estimates for sawmill and kiln plant), Trinidad (markets), Kenya (uses, portable charcoal kilns), West Africa (special uses, bending timbers, sleepers), British North Borneo (uses), Palestine (sleepers), Sudan (sleepers, joinery woods, specifications), Canada (markets, sleepers, flooring, special uses), Irish Free State (crate woods), Rhodesia (uses), Federated Malay States (markets). There are also several instances when, as a result of technical advice by the Utilization Section, the representatives in England of various parts of the Empire overseas have been able to secure a share of markets hitherto supplied from foreign sources.

Courses of Study for Research and Utilization Officers

During the period under review, six more officers have attended the Laboratory for courses of study, namely, one each from South Africa (general), India (Wood Preservation and Wood-working), Ceylon (Wood Preservation), New Brunswick University (Seasoning) and two from Australia (Timber Mechanics and Seasoning).

The total number of officers who have taken these courses is now eleven ; in addition, four officers of the Laboratory staff have accepted appointments overseas.

R. S. PEARSON,
Director.

January, 1930.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

(31*st December*, 1929)

Director of Forest Products Research : R. S. Pearson, C.I.E., F.L.S.
Assistant Director : F. M. Oliphant.
Scientific Field Assistant : A. N. David.
Publications and Records Officer : W. H. Lovegrove.
Technical Assistant (*Photographer*) : W. R. Hutchins.

Section of Wood Technology

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.
Junior Assistants : S. H. Clarke, B.Sc. ; J. C. Maby, B.Sc., A.R.C.S., F.R.A.S.

Section of Seasoning

Officer in Charge : S. T. C. Stillwell, B.Sc.
Assistant, Second Class : R. G. Bateson, B.A.
Junior Assistants : R. A. G. Knight, B.Sc. (Eng.) ; W. C. Stevens, M.A.
Timber Physicist : E. D. van Rest, B.Sc.
Junior Technical Assistants : L. S. Doman ; R. E. Hodge ; D. D. Johnston ; R. J. Newall ; N. Turner.

Section of Timber Mechanics

Officer in Charge : C. J. Chaplin, M.Sc., M.E.I.C.
Assistant, First Class : F. M. Mooney, B.Sc., A.M.E.I.C.
Junior Assistants : F. H. Armstrong, M.Sc., A.M.I.Mech.E. ; T. Hamilton, B.Sc. ; J. Latham, B.Sc. ; E. H. Nevard, B.Sc. ; Miss C. B. Pettifor, B.Sc.
Technical Assistant : Miss A. Hart, B.Sc.
Junior Technical Assistants : Miss I. M. Elliot, B.Sc. ; A. J. Foord ; Miss N. L. Forster, B.Sc.

Section of Wood Preservation

Officer in Charge : J. Bryan, M.Eng., A.M.Inst.C.E.
Junior Assistant : N. A. Richardson, B.Sc.
Junior Technical Assistant : D. N. Smith.

Section of Mycology

Officer in Charge : K. St. G. Cartwright, B.A., B.Sc.
Junior Assistant : W. P. K. Findlay, B.Sc., A.R.C.S.
Junior Technical Assistant : E. C. Badcock.

Section of Entomology

Officer in Charge : R. C. Fisher, Ph.D., B.Sc.
Junior Assistants : F. R. Cann, D.I.C. ; E. A. Parkin, B.Sc.
Junior Technical Assistant : E. C. Harris.

Section of Wood Chemistry

Officer in Charge : W. G. Campbell, B.Sc., M.S.
Junior Assistant : J. Booth, Ph.D., B.Sc., A.I.C.
Special Investigator : Miss M. H. O'Dwyer, B.Sc., D.I.C., Ph.D.

Section of Utilization

Officer in Charge : J. R. Cosgrove, D.S.O., M.C., M.E.I.C.
Assistant, Second Class : P. Harris, B.Sc.
Junior Assistant : J. A. Buchanan, B.A.
Senior Technical Assistant : J. C. Thirlwell.

APPENDIX II

LIST OF PUBLICATIONS

A.—*Stationery Office Publications**

	s.	d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 .. .. (1929)	3	0
Technical Papers :—		
No. 1.—Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. .. .. (1926)	1	6
No. 2.—Moisture Movement through Wood—The Steady State. By J. F. Martley, D.I.C., B.Sc. .. .. (1926)	1	3
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